U.S. Department of Energy

Oakland Operations Office, Oakland, California

ANNUAL SITE ENVIRONMENTAL REPORT
CALENDAR YEAR 2001

for the

LABORATORY FOR ENERGY-RELATED HEALTH RESEARCH
UNIVERSITY OF CALIFORNIA, DAVIS

Submitted to:

United States Department of Energy
National Nuclear Security Administration
Oakland Operations Office
1301 Clay Street
Oakland, California 94612-5208

Prepared by:

Weiss Associates
5801 Christie Avenue, Suite 600
Emeryville, California 94608-1827

September 2002
Rev. 0

DOE/NNSA Oakland Operations Contract DE-AC03-96SF20686

Weiss Associates
Environmental and Geologic Services

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Department of Energy
National Nuclear Security Administration
1301 Clay Street
Oakland, California 94612-5208

SEP 2 0 2002

Subject: 2001 Site Environmental Report (SER) for the Laboratory for Energy-Related Health Research (LEHR)

Dear Sir or Madam:

The enclosed 2001 LEHR SER prepared by Weiss Associates (WA) summarizes the environmental protection activities at LEHR for calendar year 2001. SERs are prepared annually for all DOE sites conducting significant environmental activities and are distributed to relevant regulatory agencies and other interested parties.

To the best of my knowledge, the 2001 LEHR SER accurately summarizes results for the 2001 Monitoring Program and Restoration Program at LEHR. This assurance is based upon a thorough review by DOE/OAK and WA, and by documented quality assurance protocols applied to the monitoring and data analysis at LEHR.

The 2001 LEHR SER is also available electronically at http://www.oak.doe.gov/Cos/Opa/Env_Rprts/Opa_EnvRptsIndex_WF.html. Please provide your comments or suggestions for future versions of the report using the enclosed reader survey form. Additionally, your questions or comments on this report may be made directly to DOE/OAK by contacting Jay Tomlin of the Oakland Environmental Programs Division at 510-637-1637.

Sincerely,

Roger H. Liddle
Acting Assistant Manager
for Environment and
Nuclear Energy

Enclosure

CERTIFICATION OF ACCURACY FOR:

ANNUAL SITE ENVIRONMENTAL REPORT, CALENDAR YEAR 2001, LABORATORY FOR ENERGY-RELATED HEALTH RESEARCH

I certify that the information submitted herein is true, accurate, and complete, based on my familiarity with the information and my inquiry of those individuals immediately responsible for obtaining the information.

Signature: Robt O. Devany Date: 9/13/02

Robert O. Devany, Project Manager

ANNUAL SITE ENVIRONMENTAL REPORT
READER SURVEY

To Our Readers:

Each Annual Site Environmental Report publishes the results of environmental monitoring at the former Laboratory for Energy-Related Health Research (LEHR) and documents our compliance with environmental regulations. In providing this information, our goal is to give our readership—whether they are regulators, scientists, or the public—a clear accounting of the range of environmental activities we undertake, the methods we employ, and the degree of accuracy of our results.

It is important that the information we provide is easily understood, is of interest, and communicates the Department of Energy's effort to protect human health and the environment. We would like to know from you, our readers, whether we are successful in these goals. Your comments are welcome.

1. Is the technical level ❑ too high? ❑ too low? ❑ uneven? ❑ just right?
2. Is the writing ❑ too concise? ❑ too verbose? ❑ uneven? ❑ just right?

	Yes	**No**
3. Do the illustrations help you understand the text better?	❑	❑
Are there enough illustrations?	❑	❑
Is the background information sufficient?	❑	❑
4. Are the methodologies being described understandable?	❑	❑
Interesting?	❑	❑
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Do they provide sufficient information?	❑	❑

Other comments:

_____

_____

_____

A business reply envelope has been attached for returning these surveys to Weiss Associates, 5801 Christie Avenue, Suite 600, Emeryville, CA 94608.

OPTIONAL

Name: _____ Occupation _____

Address: _____

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TABLES

FIGURES

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Appendix A. Isoconcentration Maps for Hydrostatigraphic Units 1and 2 from URS (2002)

ACRONYMS AND ABBREVIATIONS

ASER	Annual Site Environmental Report
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
DOE	United States Department of Energy
EPA	United States Environmental Protection Agency
HSU	hydrostratigraphic unit
km	kilometer
LEHR	Laboratory for Energy-Related Health Research
m	meters
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mrem/yr	millirem per year
MSDS	Material Safety Data Sheet
mSv	milliSievert
N/A	not applicable
NNSA	National Nuclear Security Administration
No.	number
pCi/g	picoCuries per gram
pCi/L	picoCuries per liter
PCD	Putah Creek Downstream
PCU	Putah Creek Upstream
PM_{10}	particulate matter with aerodynamic size less than or equal to 10 micrometers
PRG	preliminary remediation goal
rem	Roentgen Equivalent Man
SARA	Superfund Amendment and Reauthorization Act
STPO	wastewater (sewage) treatment plant outfall
TSCA	Toxic Substances Control Act
UC Davis	University of California, Davis

WA	Weiss Associates
WRS	Wilcoxon Rank Sum test
µCi/ml	microCurie per milliliter
µg/L	micrograms per liter
$\mu g/m^3$	micrograms per cubic meter

DISTRIBUTION

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EXECUTIVE SUMMARY

This Annual Site Environmental Report for the Laboratory for Energy-Related Health Research (the Site) at the University of California, Davis (UC Davis) summarizes the United States Department of Energy (DOE), National Nuclear Security Administration's (NNSA's) environmental performance at the Site, including environmental compliance; environmental monitoring data for air, soil, ground water, surface water, storm water and ambient radiation; and environmental management programs. DOE operation of LEHR as a research facility ceased in 1989, after three decades of research on the health effects of low-level radiation exposure (primarily strontium-90 and radium-226) on human health using beagle dogs as research subjects. Contamination from research activities resulted in the addition of the Site to the National Priorities List in 1994. In 1997, DOE and UC Davis reached an agreement on the responsibilities for site clean up. During Calendar Year 2001, DOE/NNSA continued environmental remediation and restoration activities at the Site in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act.

Progress of Site Environmental Restoration

DOE/NNSA site restoration activities are conducted in accordance with a 1999 Federal Facility Agreement entered into by DOE and the United States Environmental Protection Agency, California Department of Toxic Substances Control, California Department of Health Services and the Central Valley Regional Water Quality Control Board. Under the Federal Facility Agreement, DOE is responsible for remediation of site facilities, including the radium-226 and strontium-90 leach fields and tanks, DOE disposal box, on-site domestic septic tanks and associated systems, DOE disposal trenches, and the former dog pens (Figure 1-2). UC Davis is responsible for three landfills, disposal trenches located south and east of the Landfill No. 2, 49 waste holes, an old waste water treatment plant, ground water impacted at the Site, and surface and storm water runoff impacted by UC Davis (Figure 1-2).

DOE/NNSA activities at the Site in 2001 consisted primarily of a removal action at the former Western Dog Pens , investigation and a limited removal action at the domestic septic tanks and system areas, and the shipment for disposal of low-level radioactive waste generated during prior remediation activities.

Significant site restoration progress was made during the year. Ongoing monitoring and characterization of air, soil and water were performed to meet regulatory and program requirements. Primary DOE/NNSA activities in 2001 included:

- **Western Dog Pens Removal Action:** An Engineering Evaluation and Cost Analysis for the Western Dog Pens was finalized in January 2001 and a removal action in the Western Dog Pens was completed in 2001.

- **Domestic Septic Systems Investigation and Removal Action:** Investigation activities at the Domestic Septic Systems were conducted in the summer of 2001. These activities were intended to characterize the extent of contamination and determine the locations of the underground domestic septic systems. Except for domestic septic systems 3 and 6, the investigation results indicated that no further action is required. Domestic septic systems 3 and 6 showed elevated mercury levels and domestic septic system 3 showed radium-226 and strontium-90 levels above site background. During the 2001 investigation, a limited removal action was conducted in an area measuring approximately five feet by five feet where mercury contamination was detected. The soil around the mercury detection was excavated and containerized for off-site disposal in accordance with applicable regulations. The results of the investigation indicated a need for further remedial action and are summarized in the Action Memorandum for a Change in Scope of Response at Domestic Septic Systems 3 and 6 (WA, 2002a).
- **Eastern Dog Pens Engineering Evaluation/Cost Analysis:** An Engineering Evaluation/Cost Analysis for the Eastern Dog Pens and Western Dog Pens was finalized in January 2001 and recommended the implementation of institutional controls such as fence repairs, site monitoring and land use restrictions for the Eastern Dog Pens. The Engineering Evaluation/Cost Analysis was approved in 2001.
- **Waste Disposal:** Approximately 65,147 cubic feet (2,412 cubic yards) of low-level radioactive waste generated from the Southwest Trenches, Radium and Strontium Treatment Systems, Domestic Septic System Number 2, and the Western Dog Pens removal actions were shipped for offsite disposal at the Nevada Test Site and Envirocare of Utah during Calendar Year 2001.

Overview of 2001 Water Environmental Monitoring Results

Two major modifications to the UC Davis ground water interim remedial action were made in 2001: 1) UC Davis Land Treatment Pilot Study elements were completed to assess the feasibility of land application of interim remedial action treatment plant effluent, and 2) a mixing operation was completed to reduce total dissolved solids concentrations and nitrate levels to meet waste discharge requirements. During the shutdown of the interim remedial action system for modifications, the concentrations of chloroform in downgradient wells increased. After the system was restarted at less than the designed pumping rates, chloroform concentrations in these wells returned to pre-shutdown levels.

A density-driven convection system pilot test was also conducted by UC Davis in 2001 to assess whether the density-driven convection technology can effectively reduce the mass of chloroform present in the shallow ground water. Since the completion of the pilot test, reductions of chloroform within B-zone piezometers range from 40% to 96%. Based on the results of the pilot test, expansion of the system has been recommended.

Storm water and surface water samples collected and analyzed in 2001 were consistent with previous years, and no new trends or concerns were identified.

Overview of 2001 Air Environmental Monitoring Results

The current Site air monitoring program consists of collecting contaminant data on constituents of concern before, during and after removal actions. Gross alpha and beta monitoring was discontinued in 2001 based on data collected from 1996 through 2000, which showed no statistically significant deviation from background levels. The results of the radionuclide air monitoring program are similar to previous years and show no hazard to the site workers or the public.

Radiological Impact Assessment of the LEHR Environmental Restoration Project

The Western Dog Pens removal action and the investigation at the Domestic Septic Systems were the primary DOE/NNSA environmental restoration activities at the Site in 2001. The removal of contaminated materials and soils from these areas will reduce the long-term risk of radiological exposure at the Site. The 2001 radiological air and ambient data all indicate that detected radionuclide activities were near or below natural background levels, and do not pose a risk to site workers or the general public.

1. INTRODUCTION

This Annual Site Environmental Report (ASER) describes Calendar Year 2001 United States Department of Energy (DOE), National Nuclear Security Administration's (NNSA) environmental restoration and waste management activities at the Laboratory for Energy-Related Health Research (LEHR) (the Site) at the University of California, Davis (UC Davis) (Figure 1-1). This report was prepared according to the requirements of DOE Order 5400.1, General Environmental Protection Program and DOE Order 231.1 Environmental Safety and Health Reporting. The purpose of this report is to summarize environmental data, confirm compliance with environmental standards and requirements, and highlight significant programs and efforts. This report describes activities conducted by DOE/NNSA during 2001 in support of the Site environmental restoration efforts, and provides information about the impact of these activities on the public and the environment. A ground, surface and storm water monitoring program performed by UC Davis includes information important to the overall environmental restoration of the Site and is briefly summarized herein. The UC Davis program discussed in this report is not required to comply with the requirements of DOE Order 5400.1.

1.1 Site History

The Atomic Energy Commission first sponsored radiological studies on laboratory animals at UC Davis in the early 1950s. Initially situated on the main campus, LEHR was relocated to its present location in 1958 (Figure 1-1). Research at LEHR through the late-1980s focused on studying health effects from chronic exposure to radionuclides, primarily strontium-90 and radium-226, using beagles as research subjects. Other related research was conducted at the Site concurrent with these long-term studies. In the early 1970s, a cobalt-60 irradiator facility was constructed at the Site to study the effects of chronic exposure to gamma radiation on humans, again using beagles.

A campus landfill with two waste burial units that were used from the 1940s until the mid-1960s is located at the Site (Figure 1-2). Several low-level radioactive waste burial areas were also present at the Site, and campus and LEHR research waste was buried in these areas until 1974, in accordance with regulations in effect at the time. These radioactive burial areas have been remediated during several removal actions conducted at the Site since 1996.

In 1988, pursuant to a Memorandum of Agreement between DOE and the University of California, DOE's Office of Energy Research initiated activities to close out the research program at LEHR. In 1997, a second Memorandum of Agreement divided the responsibility for environmental remediation between DOE and UC Davis.

Under a Federal Facility Agreement effective in December 1999, DOE is responsible for remediation of radium-226 and strontium-90 treatment systems, a buried DOE disposal box, on-site domestic septic tanks and associated leach fields and dry wells, DOE disposal trenches, and the former dog pens (Figure 1-2). UC Davis is responsible for remediation of three landfills, disposal trenches located south and east of Landfill No. 2, 49 waste holes (Figure 1-2), an old waste water treatment plant, ground water impacted by the Site, and surface and storm water runoff impacted by UC Davis.

DOE/NNSA activities at the Site in 2001 consisted primarily of the Western Dog Pens removal action, Domestic Septic Systems investigation and limited removal action, and shipping of waste generated during prior removal actions (Figure 1-2).

1.1.1 Environmental Restoration

The DOE/NNSA Oakland Operations Office manages the environmental restoration of the DOE -impacted areas of the site. From October 1989 through February 1990, an interim contract with UC Davis was implemented to begin site restoration. From 1990 to 1996, Battelle Environmental Management Operations managed the LEHR remediation project. In 1996, the project was transferred to Weiss Associates (WA) of Emeryville, California.

In May 1994, the United States Environmental Protection Agency (EPA) added the Site to the National Priorities List. A site remedial investigation and feasibility study work plan was developed to ensure that investigation and remediation were conducted in accordance with applicable regulatory requirements. Remedial Project Manager meetings are generally held monthly to evaluate the progress of remediation and identify actions needed to facilitate the process.

Primary DOE/NNSA restoration/remediation activities that have been or will be performed at the Site include: soil and ground water characterization; building assessment; decontamination and decommissioning of above-ground structures; removal of contaminated underground tanks, trench structures, and contaminated soil; chemical and radiological risk assessment; and waste management. Health and safety, environmental protection and quality assurance components are integrated into the management of all remediation and site restoration activities conducted at the Site on behalf of DOE/NNSA.

1.2 Site Description

The Site is a 15-acre parcel owned by the Regents of the University of California. It is 1.5 miles south of the main UC Davis campus in a rural agricultural area (Figure 1-1), and is presently occupied by the UC Davis Center for Health and the Environment. Research at Center for Health and the Environment includes toxicology, epidemiology, radiation biology and radiochemistry.

The Site currently consists of 15 buildings, including a main administration and office building, two former animal hospitals, a laboratory and support buildings. Former facilities include: radioactive wastewater treatment systems, an indoor/outdoor cobalt-60 irradiator, a radioactive waste burial area, and outdoor dog pens. Inactive campus landfill units and numerous inactive campus disposal sites (i.e., trenches and holes) were used to dispose low-level radioactive and chemical waste and are being evaluated and/or remediated by UC Davis. Figure 1-2 shows areas that have potentially impacted the environment at the Site.

1.3 Population Data

1.3.1 Site Population

Currently, the Site is used by UC Davis Center for Health and the Environment to support ongoing research in toxicology, epidemiology, radiation biology and radiochemistry. UC Davis Center for Health and the Environment consists of several research facilities occupied by approximately 200 university researchers and support staff. Center for Health and the Environment researchers and student assistants have varying schedules and are not all present at the Site at the same time.

The LEHR remediation project is currently managed and staffed by WA and its subcontractors, and employs about six full-time workers at the Site. This number increases to approximately 15 workers when on-site remediation and waste management activities are in progress.

1.3.2 Local Population

The Site is located in a rural area in northeast Solano County just outside of Davis, California (Figure 1-1). UC Davis campus has a student population of approximately 27,000 and employs approximately 17,000 full-time faculty and staff (UC Davis News Service, Facts and Figures: 2000-2001).

The estimated 2001 population of the city of Davis is approximately 63,300, and the estimated total population of Yolo County is about 168,700 (State of California, 2002a). The more densely populated and metropolitan Sacramento area is approximately 12 miles east of the Site. The current population of Sacramento County is about 1,268,770 (United States Census Bureau, 2001), and approximately 426,000 people live in the city of Sacramento (State of California, 2002b).

1.4 Environmental Setting

The Site is located on a relatively flat plain bordered on the south by Putah Creek. The Site is mostly open, slopes gently to the east, and has a few trees and bushes. The Site lies outside the 100-year floodplain.

1.4.1 Land Use

The land within a one-mile radius of the Site is owned both privately and by UC Davis. It is used for animal research, agriculture and recreation (i.e., fishing and swimming). Privately owned lands south and east of the Site are used to produce wheat, tomatoes, corn, barley and oats and include permanent residences. Private property to the south is separated from the Site by the South Fork of Putah Creek, and private property to the east is adjacent to non-LEHR, UC Davis-owned research facilities. The property immediately west, north and south of the Site (Putah Creek Reserve) is owned by UC Davis and is currently used for various types of animal, agricultural and health research.

1.4.2 Hydrogeology

Unconsolidated Pliocene and Pleistocene sedimentary deposits are the major ground water sources for public and private water supplies in the Sacramento Valley (DWR, 1978), in which the Site is located. Both unconfined and confined fresh water aquifers are present in the uppermost 3,000 feet of the valley subsurface. Ground water generally flows from the valley sides towards the valley axis. In the Site vicinity, regional ground water generally flows east from the Coast Ranges toward the Sacramento River (Dames & Moore, 1993).

At various depths beneath the valley floor, saline water is present as a result of entrapment during the deposition of sediments in a marine environment. The depth to the base of fresh water in the Sacramento Valley varies from 400 feet to over 3,000 feet, and is 2,600 feet to 3,100 feet below ground surface in the Davis area (DOG, 1982).

Previous investigations identified five hydrostratigraphic units (HSUs) beneath the Site (Dames & Moore, 1999b). These include the vadose (unsaturated) zone and HSUs 1 through 4. The vadose zone extends from the ground surface to the top of ground water, which has historically ranged from 15 feet to 55 feet below ground surface. The vadose zone consists primarily of unsaturated clay and silt with lesser amounts of interbedded sand and gravel. HSU-1 extends from the bottom of the vadose zone to depths of approximately 76 feet to 88 feet below ground surface. This unit is lithologically similar to the vadose zone and consists primarily of silt and clay, with lesser amounts of sand and gravel. HSU-2 extends from the bottom of HSU-1 to depths of approximately 114 feet to 130 feet below ground surface. This unit is composed primarily of sand in the upper portion of the unit and gravel in the middle to lower portions. HSU-3, investigated in off-site areas, extends from the bottom of HSU-2 to a depth of about 250 feet below ground surface and

is approximately 120 feet thick. The unit consists primarily of relatively fine-grained sediments varying from very fine-grained sandy silt to clayey silt and silty clay. HSU-4, also investigated in off-site areas, extends from the bottom of HSU-3 to a depth of about 280 feet below ground surface and is approximately 32 feet thick. This unit consists of coarse sand and gravel. Beneath HSU-4, a sharp contact with a bluish, dark gray silt was encountered at 282 feet below ground surface in wells UCD4-41 and UCD4-43 (Figure 3-1). The bottom of this unit has not been penetrated in any of the site borings (Dames & Moore, 1999b).

The uppermost distinct aquifer beneath the Site has been divided into two HSUs (HSU-1 and HSU-2), based on the stratigraphy of the sediments at the Site and the associated ground water flow and contaminant migration characteristics (Dames & Moore, 1994). Well drillers' logs indicate that a 90-feet-thick clay unit separates HSU-2 from a second aquifer below (Dames & Moore, 1994).

Irrigation water, rainfall and Putah Creek recharge ground water in the Site vicinity (Dames & Moore, 1997). The main component of ground water recharge, however, has been identified as irrigation water infiltration (WA, 1998a). Ground water pumping associated with agriculture is responsible for the great majority of ground water withdrawal. In addition, UC Davis extracts ground water from HSU-2 as part of its interim remedial action.

Generally, there is a 20-feet to 30-feet seasonal fluctuation in the depth-to-ground water beneath the Site caused predominantly by the lack of surface recharge and nearby agricultural pumping in the summer. Vertical gradients vary both temporally and spatially. The magnitude of the vertical gradient is greatest when ground water elevations are rising or falling sharply. Short-term activities such as local agricultural pumping can produce downward vertical gradients during periods of an otherwise rising water table.

The HSU-1 lateral gradient across the Site typically ranges from 0.01 feet/foot to 0.04 feet/foot, and the direction of ground water flow is predominantly northeast. Representative values of HSU-1 horizontal hydraulic conductivity are between 1×10^{-4} and 1×10^{-7} centimeters per second (Dames & Moore, 1999b). The lateral gradient across the Site within HSU-2 typically ranges from 0.005 feet/foot to 0.015 feet/foot. The direction of flow appears to be predominantly northeast, although it can occasionally be east-southeast. Based on pumping tests, hydraulic conductivity in HSU-2 ranges from 0.26 centimeters per second to 0.43 centimeters per second (Dames & Moore 1997).

Ground water in HSU-1, HSU-2 and HSU-4 has been impacted by site activities. Based on investigations to date (WA, 1997a and WA, 1999a), significant ground water impacts appear to be associated only with the UC Davis disposal areas.

1.4.3 Water Supply and Quality

Ground water in the Site vicinity is used for agricultural and domestic supply. Regional ground water quality has been impacted by nitrates, probably from agricultural sources, and by hexavalent chromium, probably from natural sources.

Local ground water is recharged by streams and rivers, and direct infiltration from precipitation and irrigation. At the Site, recharge rates are highest immediately after precipitation events. Within a day after a heavy precipitation event, continuous water level measuring equipment located in monitoring wells near the creek show a significant increase (DOE, 1996).

1.4.4 Sanitary Sewer Systems

The Site discharges its sanitary wastewater to the UC Davis Wastewater Treatment Plant. UC Davis operates the plant under the conditions specified in its National Pollutant Discharge Elimination System permit, granted by the Central Valley Regional Water Quality Control Board under agreement with the EPA.

1.4.5 Storm Drainage System

Storm water runoff at the Site is collected in an underground drainage system. Storm water from the paved area in the western part of the Site and around the southern buildings in the western area is collected in a storm water drainage system. The drainage system flows to the site storm water lift station (LS-1 on Figure 3-1), and then to an outfall along the west side of Old Davis Road. Storm water in the northwestern area of the Site drains into a ditch along Old Davis Road. Storm water in the eastern and non-paved southern portions of the Site percolates into the ground, except for a section of the former cobalt-60 Field where dog pens were once located, and where drainage is connected to the sanitary sewer. Water ponds in some areas of the site during heavy rains.

1.4.6 Biological Resources

A number of sensitive biological resources were identified in an Ecological Scoping Assessment (WA, 1997b) as potentially occurring in the vicinity of the site. These species include the Giant Garter Snake, the Northern Harrier, the Coopers Hawk, the California Horned Lark, the Great Egret, the Burrowing Owl and the Valley Elderberry Longhorn Beetle, which lives in elderberry bushes. Although elderberry bushes are present at the Site, a focussed biosurvey (IT Corp, 1998) found no sensitive species actually present on site and concluded that the on-site elderberry bushes are not currently hosting the Valley Elderberry Longhorn Beetle.

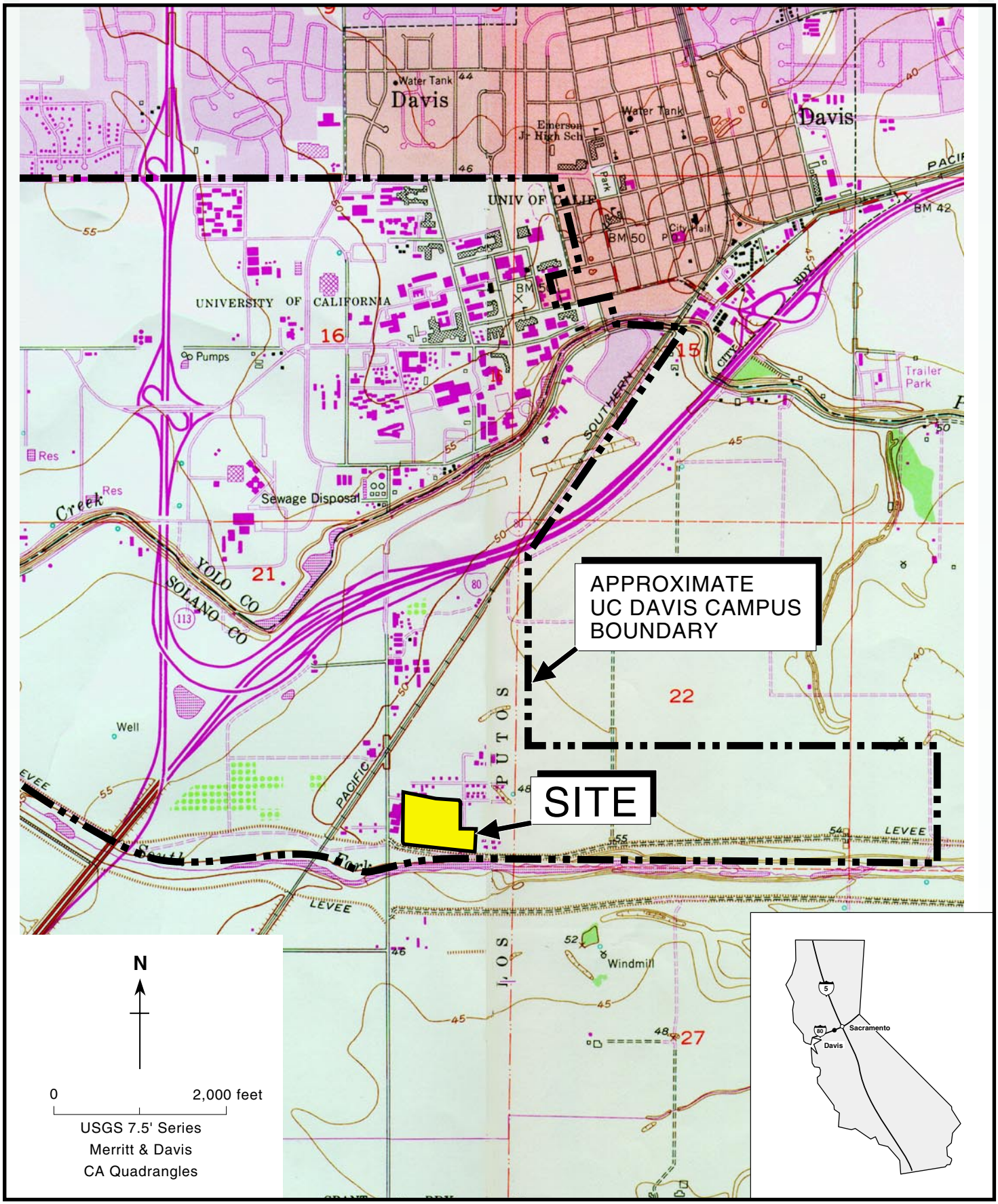

Figure 1-1. Location of the LEHR Site, UC Davis, California

Weiss Associates

Figure 1-2. Site Features and Areas of Potentially Known Contamination Source Areas

Weiss Associates

2. COMPLIANCE SUMMARY

This section summarizes the LEHR site's environmental regulatory compliance status during the environmental restoration and waste management activities conducted in the 2001 calendar year. No violations, fines or penalties were issued for the Site in 2001.

2.1 Environmental Restoration and Waste Management

Environmental restoration and waste management activities at LEHR are conducted in compliance with the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA or Superfund) and the National Contingency Plan, and include compliance with applicable or relevant and appropriate requirements and DOE Orders, as described below.

2.1.1 Comprehensive Environmental Response, Compensation and Liability Act as Amended by the Superfund Amendments and Reauthorization Act

In 1995, a streamlined remediation process was initiated at the Site using the CERCLA non-time critical removal action approach. This approach enables an expedited response to contamination problems without requiring the time-consuming investigations and decision-making involved with full remedial investigation/feasibility studies required otherwise. The removal action approach facilitates integration of clean up and data evaluation activities. In accordance with the requirements for non-time critical removal actions, an Engineering Evaluation and Cost Analysis for the Western and Eastern Dog Pens (WA, 2001k) was prepared in 2001 and approved by the overseeing regulatory agencies in January 2001. The Engineering Evaluation/Cost Analysis recommended a removal action in the Western Dog Pens and administrative controls in the Eastern Dog Pens. The removal action in the Western Dog Pens was completed in 2001.

An investigation was conducted in 2001 at the Domestic Septic Systems (septic tanks shown on Figure 1-2) to characterize the contamination, and a limited removal action was completed to remove soil with elevated levels of mercury. Sampling conducted during the domestic septic systems investigation indicated the need to remove additional soil due to residual mercury contamination in the area. This work is planned for completion in 2002.

2.1.2 Resource Conservation and Recovery Act

No hazardous or mixed hazardous and radioactive waste subject to regulation under the Resource Conservation and Recovery Act was generated or stored at the Site in 2001.

2.1.2.1 Mixed Waste Storage Facility

In 1989, UC Davis (as operator) and DOE (as owner) submitted a Resource Conservation and Recovery Act Part A permit application to EPA for the on-site storage of mixed waste generated during decontamination and decommissioning activities. Pending issuance of the Part A permit, the Mixed Waste Storage Facility operated between 1989 and 1996 under Resource Conservation and Recovery Act interim status. The facility consisted of a pre-fabricated steel chemical storage building with three separate lockers that were used to store mixed waste. The facility has been closed with the approval of the California Department of Toxic Substances Control and the building structure has been transferred to UC.

2.1.3 Federal Facilities Compliance Act

The Federal Facilities Compliance Act amends the Solid Waste Disposal Act and states that all federal agencies are subject to all substantive and procedural requirements of federal, state, and local solid and hazardous waste laws in the same manner as any private party. The act requires that a site treatment plan be prepared for each DOE site that generates or stores mixed radioactive waste. A final site treatment plan for LEHR was approved and issued in October 1995. No revisions have been made to this plan. The Site continues to be in compliance with the Federal Facilities Compliance Act.

2.1.4 National Environmental Policy Act

Consistent with DOE policy and guidance, environmental considerations for proposed removal actions and alternatives are evaluated during the Engineering Evaluation/Cost Analysis process, allowing integration of National Environmental Policy Act requirements with the CERCLA process, thereby eliminating the need for a separate National Environmental Policy Act analysis and streamlining the clean up process.

An Engineering Evaluation/Cost Analysis for the Southwest Trenches, radium-226/strontium-90 Treatment Systems and Domestic Septic System Areas was completed in early 1998 (WA, 1998b) and included an evaluation of the environmental impacts associated with the domestic septic systems removal actions conducted in 2001. The analysis found no significant impacts associated with the implementation of the domestic septic systems removal actions.

An Engineering Evaluation/Cost Analysis for the Western Dog Pens and Eastern Dog Pens was prepared in 2001 and evaluated environmental impacts of the Western Dog Pens removal action in a manner consistent with National Environmental Policy Act and with DOE environmental

compliance guidelines. The Engineering Evaluation/Cost Analysis found that the Western Dog Pens removal action and implementation of institutional controls at the Eastern Dog Pens would present no significant impacts to the human environment.

2.1.5 Toxic Substance Control Act

Concern over the toxicity and persistence in the environment of Polychlorinated Biphenyls (PCBs) led Congress in 1976 to enact Section 6(e) of the Toxic Substances Control Act (TSCA) that included among other things, prohibitions on the manufacture, processing, and distribution in commerce of PCBs. TSCA legislated management of PCBs from manufacture to disposal. In 2001, PCB-containing waste was managed at the LEHR in accordance with TSCA requirements.

2.1.6 Federal Insecticide, Fungicide and Rodenticide Act

The EPA, under the Federal Insecticide, Fungicide and Rodenticide Act, regulates the sales, distribution, and use of pesticides by requiring their registration. Registration includes approval by the EPA of the pesticide's label, which must give detailed instructions for its safe use. The EPA must classify each pesticide as either "general use," "restricted use," or both. Registered general use herbicides were applied at the Site in 2001 by the UC Davis Agricultural Services Department to control weeds. The herbicides were used in accordance with the safe use instructions and in compliance with UC Davis campus requirements, and local, state and federal laws.

2.2 Radiation Protection

All activities at the Site are conducted in compliance with Title 10 of the Code of Federal Regulations 835, Radiation Protection and applicable DOE Orders.

2.2.1 DOE Order 5400.5, Radiation Protection of the Public and the Environment

A Report on the Radiation Protection of the Public and the Environment (WA, 2001l)was developed in 2001. The purpose of this report was to evaluate LEHR operations and document their compliance with DOE Order 5400.5, Radiation Protection of the Public and the Environment. LEHR is in compliance with DOE Order 5400.5, as documented by the report.

2.2.2 DOE Order 5400.1, Environmental Protection Program

In 2001, an Environmental Protection Program (WA, 2001m) was developed which defines environmental protection activities and monitoring conducted at LEHR, including radiological

controls and monitoring requirements. This program complies with DOE Order 5400.1, Environmental Protection Program.

2.2.3 Atomic Energy Act of 1954, as Amended

Under the Atomic Energy Act of 1954, as amended, DOE has the responsibility of controlling the activities of its contractors and operations in a manner that protects the public and the environment from radiation hazards associated with its operations.

All work at LEHR is performed in compliance with the LEHR Radiation Protection Plan (WA, 1999b) and the As-Low-As-Reasonably-Achievable Plan (WA, 2001a) which comply with Title 10 of the Code of Federal Regulations, 835. The Radiation Protection Plan and As-Low-As-Reasonably-Achievable Plan require that all work performed at LEHR be conducted in a manner that protects the public and the environment from radiological hazards.

In addition to the Radiation Protection Plan and the As-Low-As-Reasonably-Achievable Plan, the LEHR Quality Assurance Project Plan (WA, 2000a) requires that environmental monitoring aspects of all operations and activities at LEHR be addressed in the work plans developed for specific activities.

2.2.4 DOE Order 435.1, Radioactive Waste Management

A comprehensive Radioactive Waste Management Basis (WA, 2001b) and Radioactive Waste Management Plan (WA, 2001c) were developed and approved in 2001, and existing standard operating procedures for waste management were updated to meet the requirements of DOE Order 435.1. All waste management activities are carried out in compliance with these documents and are conducted in a manner that protects the public, the workers and the environment from radiological hazards.

2.3 Air Quality and Protection

2.3.1 Clean Air Act

Under the Clean Air Act, the EPA has defined six criteria pollutants: carbon monoxide, nitrogen dioxide, lead, ozone, particulate matter, and sulfur dioxide, and set National Ambient Air Quality Standards for these pollutants. The only criteria air pollutant emitted at the Site is particulate matter with aerodynamic size less than or equal to 10 micrometers (PM_{10}) generated during soil excavation activities. The Site is not considered a major source of air emissions.

Since the potential exists for soil and associated contamination to become airborne during sampling and excavation activities, verification of Site compliance with the Clean Air Act is accomplished through air monitoring during these activities. Prior to the start of each phase of a project, an analysis is performed to evaluate air monitoring requirements and determine controls necessary to reduce any potential air emissions. Monitoring data are collected before, during and after the activity to verify that Clean Air Act requirements are met. The Site was in compliance with all Clean Air Act requirements in 2001 as administered by the Yolo-Solano Air Quality Management District.

Additionally, ambient air monitoring has been conducted since 1995, and computer simulations indicate that surface soil contamination does not impact air quality at the Site.

2.3.2 National Emission Standards for Hazardous Air Pollutants

Subpart H of 40 Code of Federal Regulations Part 61 protects the public and the environment from the hazards of radionuclide emissions, other than radon, from DOE facilities. It sets a limit on the emission of radionuclides that ensures that no member of the public in any year receives an effective dose equivalent of more than 10 millirem per year (mrem/yr).

The National Emission Standards for Hazardous Air Pollutants requirements primarily target point source/stack emissions. There are currently no point sources of radionuclide emissions at the Site. However, a Memorandum of Understanding between DOE and the EPA (DOE, 1995) applies the point source criteria to potential diffuse area sources at the Site.

The 2001 estimated dose to the public from the Site's diffuse area sources was calculated using surface soil radioactive contamination concentrations and assuming that dust generated during excavation activities and re-entrainment and dispersion of surface soil dust were the potential sources of emissions. The analysis of potential diffuse airborne radiological effluent sources at the Site is included in the 2000 Calendar Year Radionuclide Air Emission Annual Report (under Subpart H of 40 Code of Federal Regulations Part 61) (WA, 2001j)submitted in June 2001. Fugitive emissions modeling indicated that the maximum annual credible dose equivalent to a member of the public from residual Site contamination was 7.2×10^{-5} mrem/yr for an off-site exposure, and 1.0×10^{-3} mrem/yr for an on-site exposure, far below the 10 mrem/yr 2.3.2 National Emission Standards for Hazardous Air Pollutants effective dose equivalent limit. This analysis is discussed in more detail in Section 4 of this report.

2.4 Water Quality and Protection

2.4.1 Clean Water Act

As authorized by the Clean Water Act, the National Pollutant Discharge Elimination System permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. The Site discharges its sanitary waste to the UC Davis Wastewater Treatment Plant, which is subject to the conditions in National Pollutant Discharge Elimination System permit CA0077895 issued to UC Davis and Waste Discharge Requirement Order No. 92-040 granted by the Central Valley Regional Water Quality Control Board. No wastewater, other than sanitary waste, was discharged from LEHR to the wastewater treatment plan in 2001.

Under the Clean Water Act, EPA also controls polluted storm water runoff. In California, this function is delegated to the California Regional Water Quality Control Board, under state-wide National Pollutant Discharge Elimination System General Permits for Storm Water Discharges Associated with Industrial and Construction Activities. Although the Site does not fall under any of the industrial categories or construction activities subject to the state storm water permit requirements, a storm water sampling program described in the Revised Field Sampling Plan (Dames & Moore, 1998) is implemented at the Site and meets the state General Permit requirements. Best management practices are also used at the Site to mitigate any potential contamination in storm water runoff.

Under the Revised Field Sampling Plan (Dames and Moore, 1998), storm water samples are usually collected twice a year, once near the beginning of the rainy season after the first significant storm of the season and once near the end of the season. Surface water samples are also collected and analyzed in accordance with the Revised Field Sampling Plan. Details of the sampling and analyses are the provided in 2001 Annual Groundwater Monitoring Treatment System and Water Monitoring Report (URS, 2001) and are summarized herein in Section 3.

2.4.2 Drinking Water Requirements

Under the Safe Drinking Water Act, EPA sets standards to protect drinking water quality and drinking water sources, including rivers, lakes, reservoirs, springs, and ground water wells. The California Porter-Cologne Water Quality Act authorizes the State Water Quality Board and Regional Water Quality Control Boards to coordinate and control water quality in the state. The regional boards establish and enforce water quality standards for both surface and ground water by issuing permits for discharges of wastewater into state water bodies. The Safe Drinking Water and Toxics Enforcement Act prohibits discharge or release of chemicals known to the State of California to cause cancer or reproductive toxicity into water or onto or into land where such chemical passes or probably will pass into any source of drinking water.

Historically, contaminated liquid waste was discharged from DOE research activities to the Imhoff Treatment Facility, the Domestic Septic Tanks and the radium-226 septic system and

associated leach fields which resulted in hazardous releases to site soils. These structures and associated contaminated soils have been removed and have either been shipped off site for disposal or are awaiting shipment. Current DOE/NNSA activities at LEHR do not discharge contaminants to any drinking water sources.

According to a Memorandum of Agreement between UC Davis and DOE (DOE, 1997a), potential impacts to ground water from past site activities are to be addressed by UC Davis. UC Davis is conducting a ground water interim remedial action. Quarterly ground water and surface water monitoring has been conducted since November 1990. Monitoring activities conducted in 2001 are summarized in Section 4.

2.5 Other Environmental Statutes

2.5.1 Endangered Species Act

In 1997, an Ecological Scoping Assessment (WA, 1997b) was conducted to support the related Draft Final Determination of Risk-Based Action Standards for DOE Areas (DOE, 1997d). The Ecological Scoping Assessment (WA, 1997d) identified special status species that have a high potential to exist in or near Putah Creek, including two plant species, five invertebrates, nineteen birds, two reptiles, one amphibian and four mammals. These species and other potential receptors of concern are discussed in more detail in the Ecological Scoping Assessment. These species are considered during planning of remedial activities, so that any potential impact to them is eliminated or mitigated.

Habitat for the Valley Elderberry Longhorn Beetle, a threatened species under the Endangered Species Act, was identified in the Western Dog Pens, Eastern Dog Pens and the former cobalt-60 field. A mitigation plan was developed to ensure that no adverse effects to the beetle species or its habitat would result from remediation activities in the Western Dog Pens during in 2001. The plan was submitted to and approved by the United States Fish and Wildlife Service and implemented during the Western Dog Pens removal action. The LEHR staff are trained to recognize the habitat of this threatened beetle species and are required to protect the habitat from any interference or damage. No habitat modifications or adverse effects on the species resulted from the 2001 removal action activities.

2.5.2 National Historic Preservation Act

All areas affected by current remediation activities involve existing structures located on previously graded and developed land. An archeological evaluation was conducted during the Phase II Soil and Ground Water Characterization of the Site (DOE, 1992a). No evidence of cultural resources or historical or agriculturally sensitive areas was encountered. Prior to beginning work at the Site, the State Historic Preservation Officer is contacted to confirm findings of no effect on historic

resources, as required by Section 106 of the National Historic Preservation Act of 1996. The State Historic Preservation Officer was contacted in 2001 prior to beginning the Western Dog Pens removal action.

2.5.3 Migratory Bird Treaty

The Migratory Bird Treaty Act governs the taking, killing, possession, transportation, and importation of migratory birds, their eggs, parts and nests. No activities resulting in taking of any migratory birds, their eggs, parts or nests occurred at the Site in 2001.

2.6 Executive Orders

2.6.1 Executive Order 13148, "Greening the Government Through Leadership in Environmental Management"

Executive Order 13148 requires compliance with the Emergency Planning and Community Right to Know Act, also known as the Superfund Amendment and Reauthorization Act (SARA) Title III. SARA Title III requires facilities to provide information on the presence of hazardous chemicals and on the releases, both accidental and routine, of such chemicals into the environment. This information is used by state and local emergency agencies, hospitals, police and fire departments, and emergency response teams in responding to chemical emergencies, and is also available to the public to inform them of chemical hazards present in their neighborhood. The Toxic Release Inventory requirements of SARA apply to facilities which use large amounts of certain chemicals.

The amounts of chemicals stored and used at LEHR are minimal and include such items as gasoline and propane fuels, paints, thinners, and one dewar of liquid nitrogen. The storage, use, handling, and emergency response activities associated with these chemicals are covered by the following LEHR program documents which meet the Emergency Planning and Community Right to Know Act requirements:

- Project Health and Safety Plan (WA, 2001n), which contains a hazard communication program, including requirements for maintaining a chemical inventory and Material Safety Data Sheets;
- Contingency Plan and General Emergency Response Procedures (WA, 2001d), which cover planning, notification requirements and release notification procedures; and,
- Occurrence Reporting Plan (WA, 2000b), which addresses the release notification process.

Since only small amounts of chemicals are used at the Site, LEHR is not required to submit a toxic release inventory under Emergency Planning and Community Right to Know Act Section 313, Toxic Release Inventory Reporting. The Site compliance with Emergency Planning and Community Right to Know Act reporting requirements is summarized in Table 2-1.

Table 2-1. Status of Emergency Planning and Community Right to Know Act Reporting

EPCRA Section	Description of Reporting	Status
EPCRA Sec. 302-303	Planning Notification	Compliant
EPCRA Sec. 304	Extremely Hazardous Substance Release Notification	Compliant
EPCRA Sec. 311-312	MSDS/Chemical Inventory	Compliant
EPCRA Sec. 313	Toxic Release Inventory Reporting	Not Applicable

Abbreviations
EPCRA Emergency Planning and Community Right to Know Act
MSDS Material Safety Data Sheet

2.6.2 Executive Order 11988, "Floodplain Management"

The Site is not on a floodplain.

2.6.3 Executive Order 11990, "Protection of Wetlands"

No portion of the Site is designated as a wetland.

2.7 Other Major Environmental Issues and Actions

No violations, compliance orders or negative audit findings were issued to LEHR in 2001.

In 2001, the Western Dog Pens removal action was completed in compliance with CERCLA requirements. Additional investigation and a limited removal action were conducted in the domestic septic system areas.

Waste from the Western Dog Pens removal action and previous removal actions was shipped off site for disposal at sites approved by the EPA to receive CERCLA waste. The 2001 waste shipments included the following low-level radioactive waste:

- Approximately 690 cubic feet of soil from the Southwest Trenches removal action, shipped to Envirocare of Utah;

- Approximately 21,118 cubic feet of waste from the Radium-226 and Strontium-90 Treatment Systems (leach field and septic tanks) removal action (Figure 2-1), including soil, mud, cobbles, debris, rebar and concrete shipped to Envirocare of Utah;
- Approximately 36,858 cubic feet of soil and debris from the Radium-226 and Strontium-90 (treatment systems tanks) removal action (Figure 1-2) shipped to the Nevada Test Site;
- Approximately 2,110 cubic feet of soil, concrete, rebar, piping and covers from Domestic Septic System No. 2, shipped to Envirocare of Utah; and,
- Approximately 4,370 cubic feet of soil, asphalt and debris from the Western Dog Pens removal action conducted in 2001, shipped to Envirocare of Utah.

The following new environmental programs and procedures were developed, approved, and implemented in 2001:

- Radioactive Waste Management Basis (WA, 2001b) in compliance with DOE Order 435.1;
- Radioactive Waste Management Plan (WA, 2001c) to support the Radioactive Waste Management Basis;
- Hazard Category Evaluation (WA, 2001e) including a Radiological Safety Basis in compliance with DOE-STD-1027-92;
- Environmental Protection Program (WA, 2001f) in compliance with DOE Order 5400.1;
- Report on the Radiation Protection of the Public and the Environment (WA, 2001e), documenting compliance with DOE Order 5400.5;
- Standard Operating Procedure 43.1 (WA, 2001h), Security, to ensure shipments of low-level radioactive waste are secure and do not endanger the workers, the public, or the environment; and,
- Standard Operating Procedure 42.1 (WA, 2001h), Environmental Safety and Health Reporting, in compliance with DOE Order 231.1A.

A compliance audit conducted in 2001 according to Title 10 of the Code of Federal Regulations 835, Radiation Protection, identified no findings and a few minor program improvements, such as formally tracking on-the-job training verifications, which have been implemented.

2.8 Continuous Release Reporting

In accordance with CERCLA, non-permitted hazardous substance releases in quantities exceeding the CERCLA reportable quantity must be reported to the National Response Center. No such releases occurred at the Site in 2001.

2.9 Unplanned Releases

No unplanned releases occurred at the Site in 2001. No reports of unusual or off-normal occurrences under DOE Order 232.1 were made in 2001.

2.10 Summary of Permits

DOE/NNSA is not required to obtain any environmental permits for remediation and waste management activities conducted under CERCLA at LEHR.

3. ENVIRONMENTAL PROGRAM INFORMATION

Each year DOE monitors the air, water, and soil conditions at the Site by collecting environmental samples and evaluating relevant sample data obtained from UC Davis. This section describes the LEHR environmental monitoring program and summarizes the environmental monitoring activities conducted in 2001. The analytical results generated by this monitoring program are discussed in Sections 4, 5 and 6.

3.1 Environmental Management

LEHR environmental management is integrated into the overall management framework of the site environmental restoration and waste management activities. It includes evaluation of applicable environmental requirements, incorporation of these requirements into the CERCLA process, implementation of defined environmental controls, ongoing environmental compliance monitoring, corrective action and self-assessment procedures, and an annual management audit of the overall effectiveness of the LEHR environmental restoration and waste management program. The LEHR Quality Assurance Project Plan (WA, 2000a) defines this management and program approach, and explicitly incorporates the protection of the environment into site activities.

3.2 Environmental Protection and Monitoring Programs

The LEHR environmental management system includes the following programs and documents designed to ensure environmental protection:

- Environmental Protection Program (WA, 2001f);
- Report on Radiation Protection of the Public and the Environment (WA, 2001g);
- Radiation Protection Program (WA, 1999b);
- As-Low-As-Reasonably-Achievable Program (WA, 2001a);
- Radioactive Waste Management Program and Standard Operating Procedures (WA, 2001c);
- Hazard Category Evaluation (safety basis documentation) (WA, 2001e);
- Standard Operating Procedure 42.1, Environment, Safety and Health Reporting (WA, 2001h);
- Occurrence Reporting Plan (WA, 2000b);

- National Environmental Policy Act Environmental Assessments (WA, 1998b and WA, 2001i); and,
- Revised Field Sampling Plan (Dames & Moore, 1998) implemented by UC Davis for ground water, surface water, soil, sediment, air and biota monitoring.

3.3 Environmental Monitoring and Surveillance

The LEHR environmental monitoring program is described in Section 7 of the Final Environmental Protection Program (WA, 2001f) developed in accordance with DOE Order 5400.1. Environmental monitoring at LEHR is managed and performed by WA and its subcontractors, with the exception of ground, surface and storm water monitoring, which is currently performed by UC Davis. Environmental monitoring at LEHR is composed of two activities: effluent monitoring and environmental surveillance. Effluent monitoring involves the collection and analysis of liquid and gaseous effluent samples to characterize and quantify contaminants released to the environment. These data are used to assess the exposure of and risk to the public and to demonstrate compliance with applicable regulations. Environmental surveillance involves the collection and analysis of air, water, soil, terrestrial foodstuffs, biota, and other media on or near DOE sites, and the measurement of external radiation. These data are used to assess potential exposure to the public, evaluate impacts on the environment, and demonstrate compliance with applicable regulations. Because activities at the Site are conducted under Superfund, water, soil, and biota monitoring is integrated into the Superfund process, as discussed in the following sections.

3.3.1 Pre-Operational Monitoring

In accordance with the LEHR Environmental Protection Program (WA, 2001f), an environmental study must be conducted prior to start of any new process which has the potential for significant adverse environmental impact. The study should be not less than one year, and preferably two years before, the start of any new process to evaluate seasonal changes and be consistent with National Environmental Policy Act requirements. The study shall:

- Characterize existing physical, chemical and biological conditions that could be affected;
- Establish background levels of radioactive and chemical components;
- Characterize pertinent environmental and ecological parameters;
- Identify potential pathways for human exposure or environmental impact; and,
- Provide a basis for developing routine operational and emergency effluent monitoring and environmental surveillance programs.

Potential significant adverse environmental impacts associated with remediation activities conducted in 2001 were evaluated in an Engineering Evaluation/Cost Analysis for the Southwest

Trenches, Radium/Strontium Treatment Systems, Domestic Septic Systems (WA, 1998b); and in the Engineering Evaluation/Cost Analysis for the former Dog Pens (WA, 2001i). No significant adverse impacts were determined to result from these remediation activities.

3.3.2 Surface and Storm Water Monitoring

There are currently no active process-based effluent discharges from LEHR facilities to the environment which would require effluent stream monitoring. Surface and storm water run off are the only potential liquid effluent sources of contamination.

Certain storm drains on the LEHR site are directed into the UC Davis combined storm and sanitary sewer system and subsequently treated by the UC Davis waste water treatment plant. The plant operates under a National Pollutant Discharge Elimination System Permit No. CA0077895, which contains the waste water discharge requirements for this facility. Environmental monitoring and surveillance of the UC Davis waste water treatment plant is conducted by UC Davis and is discussed in Sections 4.3 and 5.3 of this report.

Surface water monitoring is conducted by UC Davis in accordance with a Revised Field Sampling Plan (Dames & Moore, 1998) developed to comply with EPA and DOE requirements for chemical and radiological analyses, respectively. Samples are collected at three locations along the South Fork of Putah Creek (Figure 3-1). The Putah Creek Upstream (PCU) monitoring point is located upstream of the LEHR site, the Putah Creek Downstream (PCD) monitoring point is located downstream of the LEHR site and UC Davis property, and the wastewater treatment plant outfall (STPO) monitoring station is located at the outfall of the UC Davis waste water treatment plant, which discharges into the South Fork of Putah Creek between PCU and PCD (Figure 3-1).

Surface water runoff samples are collected quarterly to coincide with ongoing LEHR project activities and are analyzed for radioactive and hazardous materials. The types of analyses are based upon those contaminants historically present at the LEHR site and are monitored as part of ongoing LEHR remediation and waste management activities.

In accordance with the Memorandum of Agreement between DOE and UC Davis (DOE, 1997a), DOE/NNSA collects storm water samples from a lift station located on the western border of the site (LS-1 on Figure 3-1) and UC Davis collects samples from the UC Davis areas of the site (LF-1 and LF-3 on Figure 3-1). The LS-1 collection point is a lift station located on the west side of the site, which pumps runoff to a ditch along Old Davis Road. All of the storm water monitoring data collected by UC Davis and DOE are included in an annual report prepared by UC Davis. In accordance with the Revised Field Sampling Plan (Dames and Moore, 1998), sampling is conducted for two separate rainfall events: (1) the first significant storm event of the rainy season to sample runoff that may carry material that accumulated on the ground surface during the summer months; and, (2) a large storm event late in the rainy season. Storm water samples are analyzed for the following possible contaminants: selected radionuclides (tritium, carbon-14, strontium-90, radium-226), metals, hexavalent chromium, nitrate, alkalinity, other cations and anions, volatile organic compounds, chloroform, semi-volatile organic compounds, formaldehyde, pesticides,

polychlorinated biphenyls, total oil and grease, suspended and dissolved solids, total organic carbon, chemical oxygen demand, and turbidity.

In 2001, UC Davis performed all surface water monitoring and monitored storm water runoff from the UC Davis areas of the Site. DOE/NNSA monitored storm water runoff from the DOE areas only. The surface water monitoring results are discussed in detail in Sections 4.3 and 5.3.

3.3.3 Ground Water Monitoring

DOE and UC Davis signed a Memorandum of Agreement (DOE, 1997a) to divide responsibility for site areas of contamination according to historical information regarding use and operation. UC Davis has assumed responsibility for ground water remediation activities because contamination of the ground water appears to be related primarily to the UC disposal areas. The primary constituents of concern in ground water are chloroform and other volatile organic compounds, chromium (primarily as hexavalent chromium) and nitrate. UC Davis is currently operating an interim remedial action system to extract and treat chloroform in HSU-2 and gather data that will aid in the assessment of ground water treatment effectiveness and the need for further ground water remedial actions.

The ground water monitoring plan for the Site is defined in the Revised Field Sampling Plan (Dames & Moore, 1998). The locations of ground water monitoring wells are shown on Figure 3-1. Twenty-three wells are monitored as part of the routine ground water monitoring program. Five of the monitoring wells (UCD1-3, 1-5, 1-6, 1-8, and 1-9) are not sampled as part of the quarterly ground water monitoring program, because they are generally dry. In the event that the water table reaches the screened interval in these wells, they are included in the on-site HSU-1 water level measurements for that period. Ground water samples are collected and analyzed on either a quarterly, semi-annual or annual basis.

In 2001, UC Davis performed all site ground water monitoring. The ground water monitoring results are discussed in Section 6.

3.3.3.1 Ground Water Protection

In addition to ground water remediation efforts conducted by UC Davis, ground water protection in 2001 was achieved through spill prevention measures implemented during site remediation and waste management activities, such as covering all storm drains near excavation activities, covering stockpiles of excavated soil and minimizing the dispersion of dust by water suppression.

3.3.4 Air Monitoring

There are currently no point sources of radionuclide or chemical emissions at LEHR. The only potential sources of air emissions are areas undergoing remediation and generating potentially

contaminated dust during construction-type activities. Under realistic conditions, airborne effluent from these sources does not require sampling for hazardous materials because there are no appreciable quantities of uncontained hazardous materials in the facilities or surface soil (Dames & Moore, 1992; BEI, 1991).

Airborne emissions of radioactive and hazardous materials from DOE-controlled facilities are subject to EPA regulations. The primary regulatory driver for air monitoring programs at DOE facilities is 40 Code of Federal Regulations, Part 61, Subpart H, 2.3.2 National Emission Standards for Hazardous Air Pollutants for Emissions of Radionuclides from DOE Facilities. The 2.3.2 National Emission Standards for Hazardous Air Pollutants requirements primarily target point source/stack emissions. However a Memorandum of Understanding between the DOE and the EPA (DOE, 1995) applies the same criteria to potential diffuse area sources that are required of point sources. The 2.3.2 National Emission Standards for Hazardous Air Pollutants regulations require that radionuclide emissions not exceed levels that would result in an effective dose equivalent of 10 mrem/yr. Measurement of emission rates is required for all release points with the potential to release radionuclides into the air that would cause an effective dose equivalent in excess of 1% of the standard (i.e., an effective dose equivalent >0.1 mrem/yr) and all radionuclides which could contribute to >10% of the potential effective dose equivalent for a release point.

Radioactive and non-radioactive materials in air have been monitored at a number of locations at and near the Site since August 1995. The locations of the current air monitoring stations are shown in Figure 4-1. The majority of radionuclide analytical results for samples collected in 2001 are close to or below the minimum detectable activity for the laboratory analysis methods. The types of monitoring conducted and the results obtained in 2001 are discussed in Section 4.1.

3.3.5 Environmental Dosimetry

Thermoluminescent dosimeters are used to quantify the exposure of on- and off-site personnel to penetrating gamma radiation. Currently, 28 locations are monitored for penetrating radiation (Figure 4-3). Thermoluminescent dosimeters are placed near perimeter fence lines, radioactive waste storage areas and various work areas around the Site. The thermoluminescent dosimeters are analyzed quarterly, and an annual gamma radiation dose is calculated for each location. The thermoluminescent dosimeter data are normalized by subtracting site background activity from each location. The results of the ambient radiation monitoring program are discussed in Section 4.4.

3.4 Site Environmental Training

Site-specific environmental training is conducted annually to instruct project personnel on environmental policies, programs and procedures; project-specific environmental controls; pollution prevention goals; and waste minimization requirements. This training is conducted as part of the Site orientation. Additional training is provided prior to any new activity that could potentially impact

the environment. Daily safety meetings reinforce this training and specify the steps needed to assure adequate environmental protection during that day's activities.

Before a worker is allowed to begin hazardous site work, he or she must complete a 40-hour Occupational Safety and Health Administration "Hazardous Waste Operations Training." In addition, each worker receives hazard communication training." This training ensures that the worker is aware of proper handling, usage and disposal of chemicals used on the job. It covers spill prevention and control, as well as proper storage and chemical disposal methods. Workers are also trained in radiological control methods to prevent the spread of radioactive contamination to the environment, and emergency response and reporting procedures to ensure proper response in the event of an incident.

3.5 Waste Minimization and Pollution Prevention

Site remediation activities generate hazardous and radioactive waste. The LEHR waste management program is committed to minimizing waste volumes by giving preference to source reduction, material substitution, decontamination, and recycling. Applicable waste minimization activities include:

- Avoiding the use of porous materials that cannot be decontaminated;
- Minimizing personal protective equipment waste through effective planning;
- Using real-time analyses to delineate the extent of contamination;
- Optimizing waste container utilization and recycling;
- Removing surface contamination from subsurface structures and pipes; and,
- Reusing uncontaminated soil and materials on site.

3.5.1 Waste Minimization Using Expedited Data Feedback

During the 2001 removal actions, process knowledge was used to remove contaminated material and structures from the Western Dog Pens, and to a limited degree, from the Domestic Septic Tank areas. Expedited data feedback was used to confirm that cleanup levels were being achieved, thereby minimizing the generation of additional waste requiring off-site disposal. In order to implement expedited data feedback, an on-site radiological laboratory was established to provide near real-time analytical results using state-of-the art instruments, including a high-purity germanium gamma spectrometer and a fiber optic sensor for selective measurement of beta radiation from strontium-90 (Beta Scint^{TM}). The use of near real-time data facilitated the segregation of clean soil from contaminated material and avoided unnecessary off-site disposal of uncontaminated material as low-level radioactive waste. This approach avoided generation, packaging, transportation and disposal of approximately 310 cubic yards of low-level radioactive waste during the Western Dog

Pens removal action, realizing a project cost saving of approximately $130,510, in addition to preserving valuable landfill space.

3.5.2 Use of Innovative Packaging to Preserve Landfill Space

During 2001, LEHR continued to use soft-sided containers for radioactive and hazardous waste packaging. Soft-sided containers conform to the packaged waste, optimizing container loading by minimizing void space, which preserves valuable landfill space and avoids disposition costs. Void space in traditional packages (drums, steel boxes, etc.) is between 10% and 20% depending on the size, shape and density of the waste. The LEHR site preserved an estimated 148 to 296 cubic yards of disposal facility capacity by using soft-sided containers.

3.5.3 Reuse of Excess Electronic Equipment

Land disposal of certain electronic equipment is prohibited because of hazardous levels of metals in monitors and circuitry. A local vendor was identified by DOE/NNSA-Oakland that refurbishes computers to benefit charitable organizations and/or disassemble the equipment to reclaim metal, glass and plastic. LEHR salvage and excess computer equipment was delivered to the Alameda County Computer Resource Center in Oakland, California for reuse and/or recycling on December 6, 2001. In total, the LEHR site donated:

- 13 computers;
- 10 keyboards and mice;
- 9 monitors;
- 4 printers;
- 1 box of miscellaneous external drives, hardware and cables;
- 1 typewriter; and,
- 1 scanner.

The Alameda County Computer Resource Center is utilized by other DOE/NNSA-Oakland sites to disposition excess electronic equipment, and was verified by the LEHR project as a suitable local recycling and reuse vendor. Per DOE/NNSA-Oakland's direction, the hard drives of the computers were sanitized and/or physically destroyed prior to donation to ensure that sensitive data was not distributed.

3.5.4 Recycling

In 2001, a new recycling program was instituted at LEHR and as described below.

3.5.4.1 Plastic Container Recycling

As part of the LEHR heat stress prevention program, site workers are encouraged to drink bottled water and sports drinks to remain hydrated. The ten to 20-person crew consumes approximately 300 bottles of liquids per week. In July of 2001, WA staff introduced polyethylene bottle recycling bins, provided by the UC Davis recycling center to the remote work areas. In 2001, approximately 3,000 polyethylene containers were recycled.

3.5.4.2 Cardboard Recycling

The LEHR site is located at Center for HE, an active satellite facility of UC Davis, employing approximately 125 to 150 individuals. LEHR staff receive and ship materials and equipment through the Center for Health and the Environment infrastructure and noticed that the site sanitary waste receptacles were constantly filled with cardboard boxes. In 2001, at the request of WA staff, the UC Davis recycling program delivered two 2-cubic yards cardboard recycling bins that are utilized by the ten to 20 LEHR employees and approximately 200 Center for Health and the Environment employees. Use of these bins reduces the volume of sanitary waste by approximately 6 cubic yards per month and, has saved approximately 75 cubic yards of recyclable cardboard from disposal as sanitary waste. Because the Center for Health and the Environment facility operations will continue as part of the UC Davis mission for decades to come, the lifetime reduction of waste as the result of this initiative will be measured in the many hundreds of cubic yards.

3.6 Protection of Biota

A biota investigation was conducted at LEHR (WA, 1997d), that included sampling and analysis for radioactivity of leaves from a Fruitless Mulberry tree located in the DOE Disposal Box (Figure 2-1), 3.5 feet from its northern boundary. The results of these analyses indicated no measurable impact to these leaves. In early 1997, a field survey was conducted for the ecological assessment to characterize and describe aquatic and terrestrial habitats, and actual or potential ecological receptors at the site. In 2000, samples of a tree associated with the strontium-90 treatment system leach field were collected and analyzed for radiological constituents of concern. Analytical results indicated an uptake of cesium-137 and strontium-90 in the tree. The uptake seems to be related to the contamination in the treatment system area, which has been remediated. The tree was disposed of as low-level waste.

Continuing site investigations indicate that contaminant releases from DOE activities are limited to specific areas of the LEHR site and have not affected ecological values outside of these areas. The areas of contamination at the site have been or are in the process of being remediated.

DOE Order 5400.5 and the interim DOE Technical Standard, " A Graded Approach for Evaluating Radiation Does to Aquatic and Terrestrial Biota" (DOE, 2000) provide guidance on monitoring aquatic biota and terrestrial foodstuffs, a broad category that includes vegetation and fauna. Surveillance of terrestrial foodstuffs is required to quantify radioactive materials and chemicals, and to demonstrate that radioactive and hazardous materials are not accumulating in the

environment. Currently, no sampling of terrestrial foodstuffs is planned at LEHR. A site-wide risk assessment that will evaluate the site ecological risks will be conducted after the completion of all remediation activities. Surveillance requirements will be evaluated and/or developed based on the information obtained in this risk assessment.

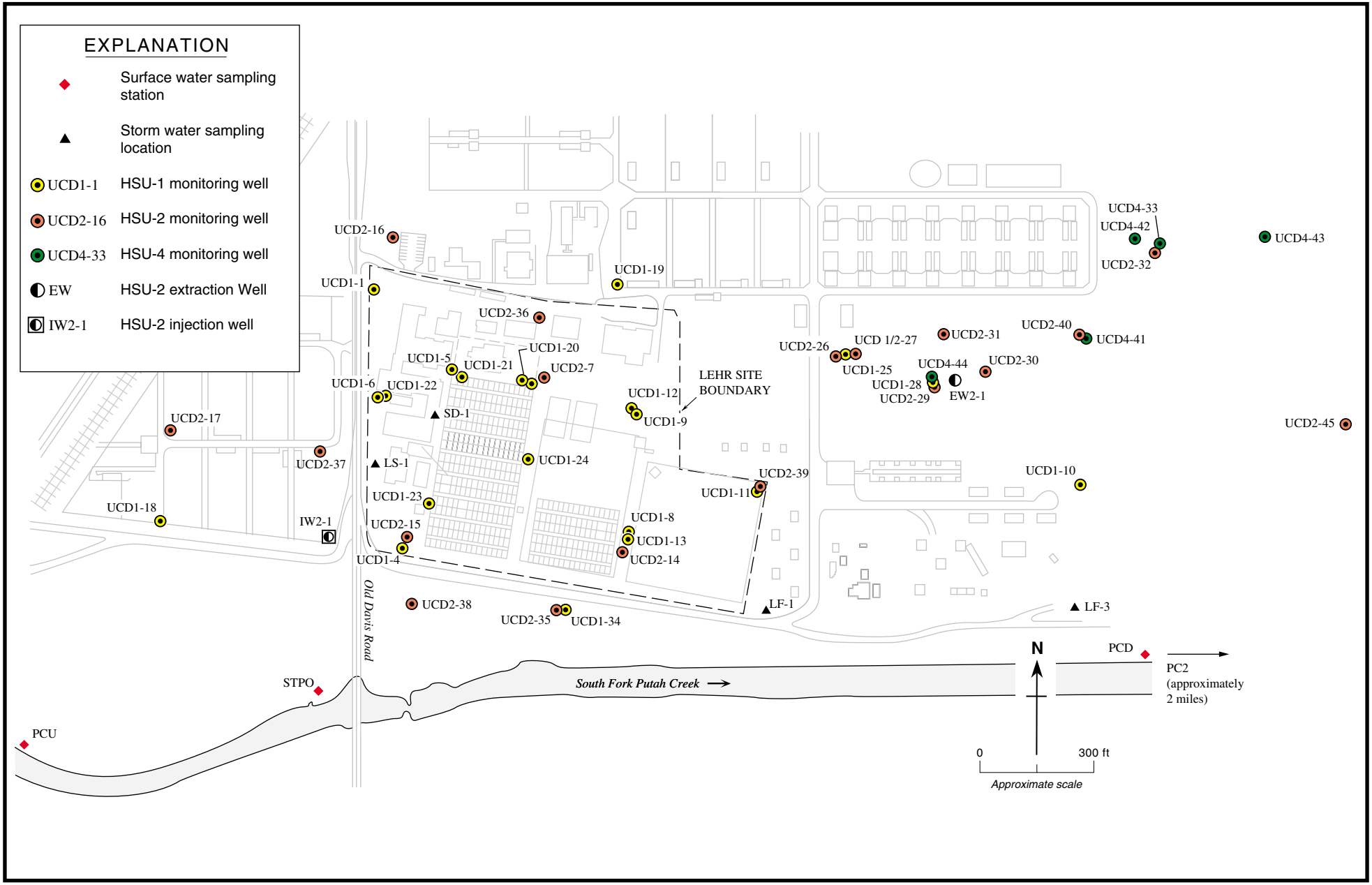

Figure 3-1. Ground Water, Storm Water and Surface Water Monitoring Locations

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4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

This section summarizes significant results and trends in radiological air, soil, and water monitoring data for 2001. The majority of radionuclide sample results for samples collected at the Site are close to or below the minimum detectable activity for the laboratory analysis methods.

4.1 Radiological Air Monitoring

Atmospheric releases of pollutants from the Site are a potential source of human exposure. Therefore, radioactive and non-radioactive materials in air have been monitored at a number of locations at and around the Site since August 1995. The locations of the current air monitoring stations are shown in Figure 4-1.

The influence of LEHR emissions on local air pollutant concentrations is evaluated by comparing air concentrations measured at a background location to those measured at the Site. The current air monitoring program includes collection of air samples at three on-site stations (AM-2, AM-5 and AM-7) and one remote background station (AM-3). Station AM-7 is a mobile station and is positioned upwind of remediation activities prior to their start. The 2001 monitoring program consisted of:

- Pre- and post-removal action monitoring for radium-226 and strontium-90 at all three on-site stations and the background station;
- Monthly monitoring during remediation action activities for radium-226 and strontium-90 at all three on-site stations and the background station; and,
- Continued collection of meteorological data at the on-site meteorological station.

Sampling for tritium, total alpha, total beta, and composite sampling for gamma-emitting radionuclides has been eliminated from the monitoring program. Total alpha and beta radiation monitoring was discontinued in 2001. Data collected and analyzed from 1996 through 2000 indicate that both the average and maximum activities of total alpha and total beta radiation were not statistically different than the background radiation. By December 2000, all major sources of radiation emissions had been removed, and it was deemed sufficient to monitor for radionuclides specific to site activities, which in 2001 were identified as radium-226 and strontium-90.

Given the lack of major source of radiation, the current air monitoring program is conservative and coupled with historical data, including earlier RESRAD modeling which

determined the non-point source radionuclide emissions to be insignificant, ensures compliance with all applicable federal regulations and DOE orders.

4.1.1 2001 Radiological Air Monitoring Program Results

Air sampling was performed at the Site during the 2001 removal actions to monitor potential releases of radionuclides into ambient air. Based on the constituents of concern detected in soil at the Western Dog Pens prior to the 2001, removal action sampling for radium-226 and strontium-90 was conducted monthly as well as pre-, and post-removal action.

Strontium-90 was not reported above the detection limit in any of the air samples collected during the Western Dog Pens removal action. Radium-226 was detected above the detection limit in seven of 20 samples at concentrations ranging from 5.38E-17 to 6.94E-15 microCuries per milliliter. The maximum concentration was well below the Derived Concentration Guide. Table 4-1 presents the average and maximum concentrations, Derived Concentration Guides for radium-226, the only radiological contaminant of concern with concentrations greater than the detection limit. On-site air monitoring data collected during the Western Dog Pens removal action indicated that ambient air concentrations did not pose any health risks to site workers or laboratory personnel at LEHR.

4.1.2 National Emission Standards for Hazardous Air Pollutants Dose Estimation Calculations

Calculations were performed to determine the estimated radiation dose from site sources to the public. During 2001, the Western and Eastern Dog Pens were identified as two potential non-point diffuse sources of radionuclide emissions generated by wind-blown, fugitive dust. Based on the surface and shallow soil sampling results from the Western Dog Pens and Eastern Dog Pens, surface contamination is conservatively assumed to exist across the entire area of each potential radionuclide non-point emissions source. The 2001 Western Dog Pens removal action was a significant change to site conditions that could have resulted in emissions different from those estimated in the Radionuclide Air Emission Annual Report for Calendar Year 2000 (WA, 2001j). Since the emissions from the Western Dog Pens removal action were assumed to come from the upper two feet of soil in the Western Dog Pens, emissions from this area were not significantly different than from prior years before the removal action was completed.

Compliance with the 2.3.2 National Emission Standards for Hazardous Air Pollutants requirements for diffuse, non-point source emissions was assessed using the EPA atmospheric dispersion/radiation dose calculation computer code, CAP88-PC Version 1.0. This code was used to calculate the effective dose equivalent to individual receptors at various distances from the Western Dog Pens and Eastern Dog Pens. A total of two “individual receptor” CAP88-PC runs were executed to model the fugitive dust emission sources. For each of the two potential radionuclide emission non-point sources, a human receptor was identified in each of the north, south, east and west quadrants relative to the source.

The CAP88-PC computer code was then used to calculate the effective dose equivalent to individual receptors at various distances and from each of the potential LEHR facility radionuclide emission sources. The reported effective dose equivalent to a maximally exposed individual at the LEHR facility includes contributions from the Western Dog Pens and Eastern Dog Pens. Based on the combined non-point source exposures, the maximally exposed individual at the LEHR facility is located in the Reproductive Biology Laboratory (Building H-215) (Figure 1-2). The results of the assessment are shown in Table 4-2.

Conservative radionuclide emission rates in fugitive dust were estimated using maximum soil radionuclide activities above the Western Dog Pens and Eastern Dog Pens backgrounds and were used to calculate the total estimated contribution to the effective dose equivalent. The total contribution to the effective dose equivalent for an on-site maximally exposed individual resulting from non-point source emissions was estimated to be 1.0×10^{-3} mrem/yr (1.0×10^{-5} milliSieverts per year), far below the 10 mrem/yr standard (Table 4-3).

The CAP88-PC computer code was also used to calculate the collective population dose, as required by DOE Order 5400.5. The collective population equivalent dose to Davis residents was 2.19×10^{-4} person-roentgen equivalent man per year (Table 4-3), and the effective dose equivalent for the off-site maximally exposed individual was 7.20×10^{-5} mrem/yr, as estimated by CAP88-PC. The calculated effective dose equivalent for the off-site maximally exposed individual is several orders of magnitude below the 10 mrem/yr standard, as required by Title 40 of the Code of Federal Regulations, Part 61 Subpart H.

4.2 Radiological Soil Measurements

This section summarizes 2001 field activities and important soil analytical results for radiological compounds for the DOE areas at the Site. The analytical results for non-radiological compounds are discussed in Section 5.

Soil sampling was performed in the Western Dog Pens and domestic septic systems areas in 2001. Soil samples were shipped to a contract laboratory for the requested suite of analyses. Full descriptions of the soil sampling methods, procedures for sample preparation and shipment, requested analyses and minimum detectable activity limits, along with the associated quality assurance/quality control requirements, are contained in the relevant work plans and reports.

4.2.1 Western Dog Pens

As discussed in Section 2, a removal action was conducted at the Western Dog Pens (Figure 1-2) in 2001. Based on a statistical evaluation of the Western Dog Pens soil data, all of the soil removed during the Western Dog Pens removal action, with the exception of the soil stored in Aisle 3 of the dog pens (Figure 4-2), was returned to the excavation after on-site screening for radium-226 and strontium-90 indicated that re-use of the soil was appropriate. After completion of the Western

Dog Pens removal action, confirmation samples were collected from the Western Dog Pens shallow soil and analyzed for radium-226, strontium-90, and chemical constituents as further discussed in Section 5.

A total of 38 confirmation samples (including 5 field duplicates) were collected from the Western Dog Pens excavation. All of the radium-226 results were below the preliminary remediation goals and site background concentration. Strontium-90 was detected above background in 11 samples, but all concentrations were below the lowest risk-based action standard (10 pCi/gm) (WA, 1997d) and preliminary remediation goal (14 pCi/gm) (EPA, Region 9).

In addition to soil samples, five cobble samples (including one field duplicate) were collected during confirmation sampling. The maximum reported radium-226 activity, 0.664 pCi/g, was detected in one cobble sample collected two feet below ground surface in pen D-21 (Figure 4-2). The soil beneath each of the cobble sample locations was also sampled and analyzed for all constituents of concern.

The confirmation sample data are evaluated in detail in the Draft Western Dog Pens Area Removal Action Confirmation Report (WA, 2002b). This evaluation included a human health risk analysis based on the site-specific risk-based action standards. The human health risk analysis indicated that the removal action activities reduced the cumulative cancer risk to a nominal range of 10^{-4} to 10^{-6}. The risk analysis determined that the non-cancer Hazard Index was reduced below 1.0.

4.2.2 Domestic Septic Systems

During the 2001 domestic septic systems investigation, five soil borings were drilled surrounding domestic septic system 3 where radium-226 was previously detected at a maximum concentration of 1.45 pCi/g. Seventeen soil samples (including two field duplicates) were collected from the five borings and analyzed for gamma emitters and radium-226.

Radium-226 was detected above its soil background levels for depths greater than four feet below ground surface and lowest risk-based action standard values. Radium-226 was detected above the soil background level of 0.75 pCi/g in two domestic septic system 3 area samples. The maximum reported concentration of radium-226, 2.44 pCi/g, was detected in a soil sample collected beneath the first point of perforation on the eastern leach line. The radium-226 contamination appears to be limited to the distribution box sediment and an area immediately below the first point of perforation. A limited removal action was completed to remove the radium-226 contamination. Confirmation samples collected after the removal action indicated that the radium-226 had been remediated.

4.3 Radiological Surface and Storm Water Monitoring

Quarterly surface water sampling has been conducted at the Site since 1990 for an extensive list of analytes. In 1997, in accordance with the Memorandum of Agreement, responsibility for

surface water sampling was transferred to UC Davis. DOE/NNSA retained responsibility for storm water runoff sampling in the DOE areas of the site. Trends and conclusions drawn from the surface and storm water monitoring results are briefly discussed below. A detailed discussion of results, including tables summarizing the analytic data, can be found in the 2000 Annual Groundwater Treatment System and Water Monitoring Report (URS, 2001).

4.3.1 Surface Water Monitoring

In 2001, UC Davis collected six surface water samples from three locations: PCU, STPO, and PCD (Figure 3-1). Samples were collected during two rainfall events on January 11 and December 20, 2001 and analyzed for carbon-14, radium-226, strontium-90 and tritium. During the January 11, 2001 sampling event, carbon-14 was detected at STPO at 25.3 ± 7.27 picoCuries per liter (pCi/L), above the contract-required detection limit. In 2000, one carbon-14 sample at PCD was also found in excess of the contract-required detection limit. Previous carbon-14 analyses of samples collected at PCD and STPO during the prior three years were below detection limits (URS, 2001). No other radionuclides were detected above the contract-required detection limit in 2001.

4.3.2 Storm Water Monitoring

The 2001 storm water monitoring program consisted of collecting a total of seven samples, including one duplicate sample. For each sampling event, a sample was collected from three storm water runoff locations shown on Figure 3-1. Grab samples were collected on January 10, 2001 at sample locations LF-1 and LF-3; on January 11, 2001 at sample location LS-1; on November 12, 2001 at sample location LS-1; and December 20, 2001 at sample locations LF-1 and LF-3. The January samples represent the 2000/2001 rainy season and the November/December samples represent the 2001/2002 rainy season. Table 4-4 provides the sample results for radionuclides.

All radiological constituents were below their respective contract-required detection limit s with the exception of gross beta at LS-1, detected at 4.84±1.19 pCi/L in January 2001 and at 4.76±1.14 pCi/L in November 2001, above the 3.0 pCi/L contract-required detection limit. In 2000, gross beta was also detected at LS-1 at 6.11 ±1.37 pCi/L. An occasional detection of gross beta is consistent with historical data.

4.4 Passive Thermoluminescent Dosimeter Monitoring Program

The LEHR ambient radiation monitoring program uses thermoluminescent dosimeters to monitor gamma radiation throughout the site. The thermoluminescent dosimeters are placed near perimeter fence lines, radioactive waste storage areas and various work areas around the Site (Figure 4-3). The thermoluminescent dosimeters are collected quarterly, and an annual gamma radiation dose is calculated for each location. In 2001, thermoluminescent dosimeters and analyses were provided by Radiation Detection Company, which is certified by the National Voluntary Laboratory

Accreditation Program. TLD-35, located at the equine center to the north of the Site, is used to monitor background activity.

The annual background dose near the Site measured by TLD-35 was 89 mrem/yr, which is consistent with previous years. The annual dose at the Site exceeded the background at only one location, TLD-A, where the total dose was 141 mrem/yr. The location of TLD-A is at a building used for storing legacy radioactive sources and standards. The total dose measured at this location has historically been higher than the background dose but below the DOE limit for public exposure. The building is not normally occupied and access is limited to trained personnel.

In all other locations the radiation dose was consistent with the site background. The DOE limit for exposure of members of the public as a consequence of routine DOE activities is 100 mrem/yr. Calendar Year 2001 thermoluminescent dosimeter results show that ambient radiation detected at the Site is well below the DOE dose limit for the general public. One sample exceeded the background by 52 mrem/yr, which is a little more than half of the dose of 100 mrem/yr allowed for DOE activities. This result is from a dosimeter located near the Geriatric I building where radioactive sources and standards were stored in 2001. Most of these sources, with the exception of one small cylinder of thorium, have been shipped offsite for reuse or disposal. Table 4-5 provides all gamma radiation dose data for 2001.

Table 4-1. Statistical Test Results Summary for the Western Dog Pens Removal Action Air Monitoring Data

Contaminant of Concern	Average Concentration ($\mu Ci/m^3$)	Maximum Concentration ($\mu Ci/m^3$)	Derived Concentration Guide ($\mu Ci/ml$)
Radionuclides			
Radium-226	2.72E-15	6.94E-15	1E-12 [1]

Notes
Data sufficiency calculations could not be run for Wilcoxon Rank Sum tests because there are no established air background concentrations.
[1] Derived Concentration Guide value is for lung retention class "W".

Abbreviations
µCi/ml microCuries per milliliter
$\mu g/m^3$ micrograms per cubic meter

Table 4-2. Summary of On-Site Effective Dose Equivalent to Maximally Exposed Individual Resulting from Radionuclide Emissions from Each Potential Fugitive Dust Emission Non-Point Source

Maximally Exposed Individual Receptor Description	Western Dog Pens Area		Eastern Dog Pens Area		Maximum Total Dose
	(mrem/yr)[1]	Location[2]	(mrem/yr)[1]	Location[2]	(mrem/yr)[3]
Specimen Storage Building (Building H-216)	9.8E-04	157 feet W	6.5E-05	433 feet W	**1.0E-03**
UC Davis Building E of LEHR Site	5.2E-05	984 feet E	4.2E-05	590 feet E	9.4E-05
Off-Site Receptor S of Putah Creek	4.7E-05	3,937 feet S	9.8E-07	2,380 feet S	4.8E-05
Off-Site Receptor W of LEHR Site	5.7E-05	1,312 feet W	4.8E-06	1,640 feet W	6.2E-05
Animal Hospital Building No. 1 (Building H-219)	4.5E-04	214 feet W	4.2E-05	541 feet W	4.9E-04
Inter-Regional Project No. 4 Building (Building H-217)	7.2E-04	170 feet W	5.5E-05	469 feet W	7.8E-04
Animal Hospital Building No. 2 (Building H-218)	4.5E-04	213 feet W	4.2E-05	541 feet W	4.9E-04
Cellular Biology Laboratory (Building H-294)	5.4E-04	213 feet N	4.8E-05	492 feet NNE	5.9E-04

Notes

[1] The effective dose equivalent to the maximally exposed individual is taken as the maximum modeled dose within a 22.5° sector in the direction and at the distance indicated in the "Location" column. The dose 65 m north of the Western Dog Pens Area, for example, would be the maximum modeled dose at 213 feet (65 meters) N, 213 feet NNE and 213 feet NNW.

[2] The distance from an area source to a receptor is defined by CAP88-PC as distance from the centroid of the area source to the receptor (US EPA, 1992b). For the LEHR facility CAP88-PC modeling, the distance from an area non-point source to a receptor is measured as the approximate distance from the centroid of an area non-point source to the centroid of the building assumed to house the receptor.

[3] The maximum total dose is the sum of effective dose equivalents modeled for each maximally exposed individual receptor from the three potential radionuclide fugitive dust emission non-point sources. Value in boldface is the maximum total dose for the site-wide maximally exposed individual.

Bold indicates highest calculated dose.

Abbreviations

E	east
ft	feet
m	meters
mrem/yr	millirem per year
N	north
NNE	north by northeast
NNW	north by northwest
No.	number
S	south
UC Davis	University of California, Davis
W	west

Table 4-3. LEHR Radiological Dose Reporting Table for Calendar Year 2001

Pathway	Dose to Maximally Exposed Individual [1]		% of DOE 100 mrem/yr Limit	Estimated Population Dose		Population within 80 km[2]	Estimated Background Radiation Population Dose
	(mrem)	(mSv)	%	(person-rem)	(person-Sv)		(person-rem)
Air	1.0E-03	1.0E-05	1.0E-03	2.2E-04	2.2E-06	111,228[3]	N/A
Water[4]	-	-	-	-	-	-	N/A
Other Pathways[5]	N/A	N/A	N/A	N/A	N/A	N/A	N/A
All Pathways	1.0E-03	1.0E-05	1.0E-03	2.2E-04	2.2E-06	111,228[3]	Not Available

Notes

[1] The effective dose equivalent to the maximally exposed individual is taken as the maximum modeled dose within a 22.5° sector in the direction and at the distance indicated in the "location" column. The dose 65 m north of the Western Dog Pens Area, for example, would be the maximum modeled dose at 213 feet (65 meter)s N, 213 feet NNE and 213 feet NNW. The maximum total dose is the sum of effective dose equivalents modeled for each maximally exposed individual receptor from potential radionuclide fugitive dust emission non-point sources.

[2] The total population used in calculating the population dose included receptors within a distance of 10 kilometers (km) (6.2 miles) from the Site, rather than 80 km (49 miles) as specified in DOE guidance. This modification was necessary to avoid including the large number of receptors in the Sacramento area whose exposure to radionuclides resulting from the Site would be negligible, but whose population numbers would have a large effect on the collective population dose results. This approach is appropriate for calculating the collective population dose for the primarily rural LEHR facility surroundings.

[3] Pathway-specific population is not significantly different from total population.

[4] The water pathway was not measured.

[5] There are no other exposure pathways contributing to a radiological dose at LEHR.

Abbreviations

km	kilometer
LEHR	Laboratory for Energy-Related Health Research
mrem/yr	millirem per year
N/A	not applicable
NNE	north by northeast
NNW	north by northwest
rem	Roentgen equivalent man
mSv	milliSievert

Table 4-4. LEHR Storm Water Radionuclide Monitoring Results for Calendar Year 2001

Analyte	CRDL pCi/L	LF-01 1/10/01	LF-01 12/20/01	LF-01 12/20/01 Duplicate	LF-03 1/10//01	LF-03 12/20/01	LS-01 1/11/01	LS-01 11/12/01
Actinium-228	20	-	-	-	-	-	0.00±31.9	6.66±6.52
Bismuth-212	70	-	-	-	-	-	5.98±35.6	2.97±13.7
Bismuth-214	10	-	-	-	-	-	5.11±4.42	3.51±7.55
Carbon-14	20	-1.55±6.31	-3.78±6.21	-2.47±5.97	0.775±6.41	-3.08±5.09	4.31±5.16	2.38±5.32
Cesium-137	10	-	-	-	-	-	1.83±2.14	-1.01±1.92
Cobalt-60	10	-	-	-	-	-	2.34±2.32	0.4851.88
Gross Alpha	2	-	-	-	-	-	0.304±0.604	1.61±1.13
Gross Beta	3	-	-	-	-	-	4.84±1.19	4.76±1.14
Lead-210	450	-	-	-	-	-	211±381	268±468
Lead-212	10	-	-	-	-	-	2.76±6.49	1.6±4.72
Lead-214	10	-	-	-	-	-	2.92±8.86	2.85±5.68
Potassium-40	100	-	-	-	-	-	0.00±31.6	48.8±25.3
Radium-226	1	0.451±0.361	0.224±0.243	0.578±0.266	0.504±0.282	0.746±0.302	0.129±0.200	0.183±0.254
Sodium-22	10	-	-	-	-	-	-0.0457±2.2	-0.231±1.63
Strontium-90	1	-0.0103±0.3	0.0568±0.13	0.0406±0.16	-0.1125±0.39	0.188±0.149	0.0291±0.40	0.347±0.414
Thallium-208	5	-	-	-	-	-	3.85±2.64	1.08±1.90
Thorium-234	200	-	-	-	-	-	0.00±128	59.9±85.1
Tritium	300	-224±130	52.2±105	77.6±108	-170±136	104±110	-223±283	0.172±0.097
Uranium-235	25	-	-	-	-	-	15.1±14.0	1.71±14.3
Uranium-238	500	-	-	-	-	-	0.00±128	59.9±85.1

Abbreviations
CRDL Contract-required detection Limit
LEHR Laboratory for Energy-Related Health Research
pCi/L picoCuries per liter
- Not analyzed

Table 4-5. LEHR Thermoluminescent Dosimeter Monitoring Results for Calendar Year 2001

Sample Location Number[1]	Total Annual Dose (mrem)	Dose Associated with DOE Activities[2] (mrem)
TLD-01	87	ND
TLD-02	86	ND
TLD-03	71	ND
TLD-07	81	ND
TLD-08	84	ND
TLD-09	80	ND
TLD-11	80	ND
TLD-12	81	ND
TLD-13	83	ND
TLD-14	103	14
TLD-15	81	ND
TLD-16	73	ND
TLD-17	78	ND
TLD-18	79	ND
TLD-19	85	ND
TLD-20	85	ND
TLD-21	80	ND
TLD-23	77	ND
TLD-24	84	ND
TLD-25	86	ND
TLD-26	80	ND
TLD-35 (Background)	**89**	**0**
TLD-36	66	ND
NWDP	84	ND
E WDP	80	ND
S WDP	79	ND
W WDP	81	ND
TLD-A	**141**	**52**
TLD-B	79	ND

Notes

[1] Location corresponds to Figure 4-3.

[2] Measured dose, less background.

[3] Background is measured at TLD-35

Abbreviations

DOE	United States Department of Energy
TLD	thermoluminescent dosimeter
mrem	millirem
ND	None detected above background

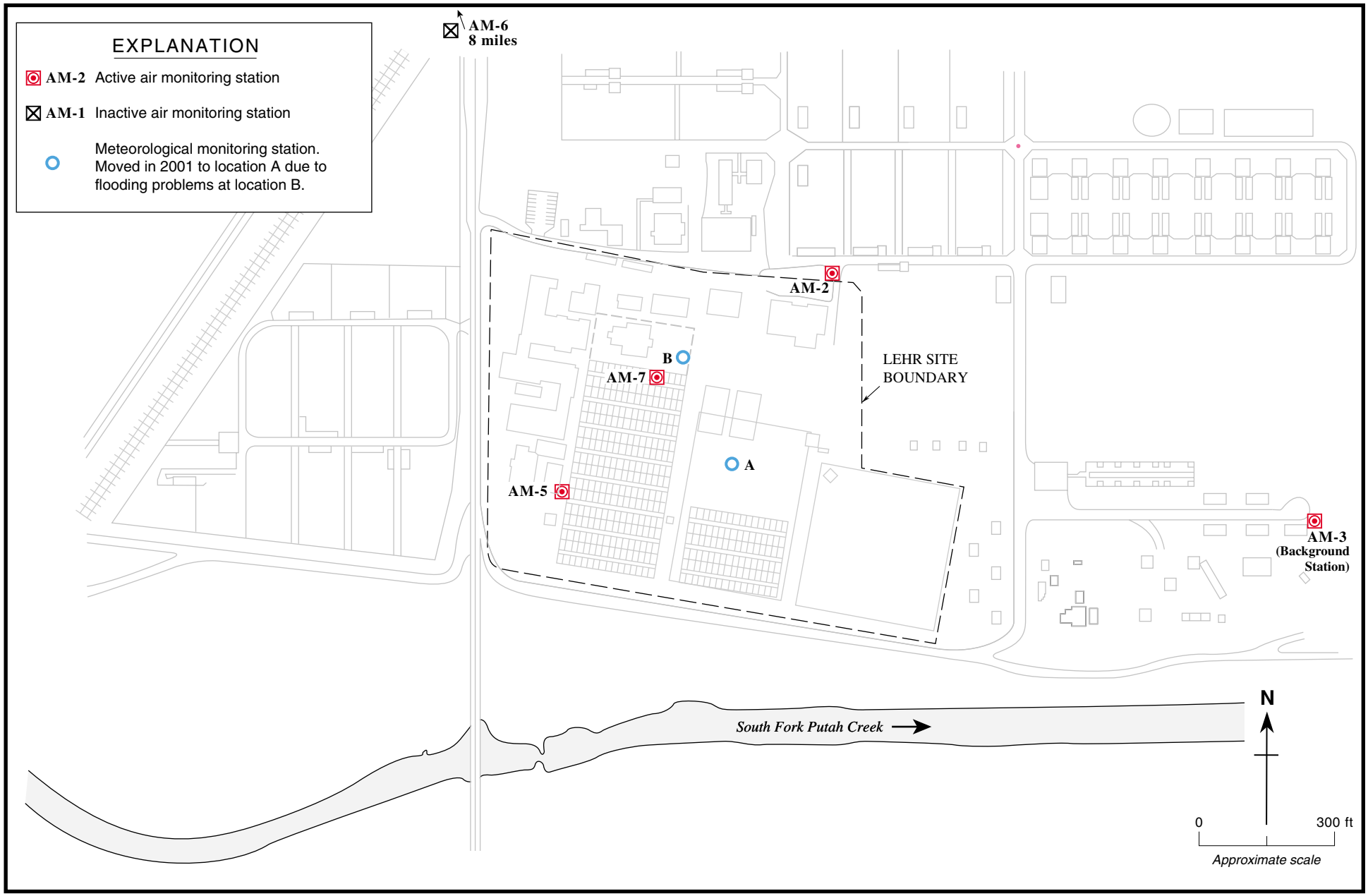

Figure 4-1. Air Monitoring Station Locations, LEHR Site

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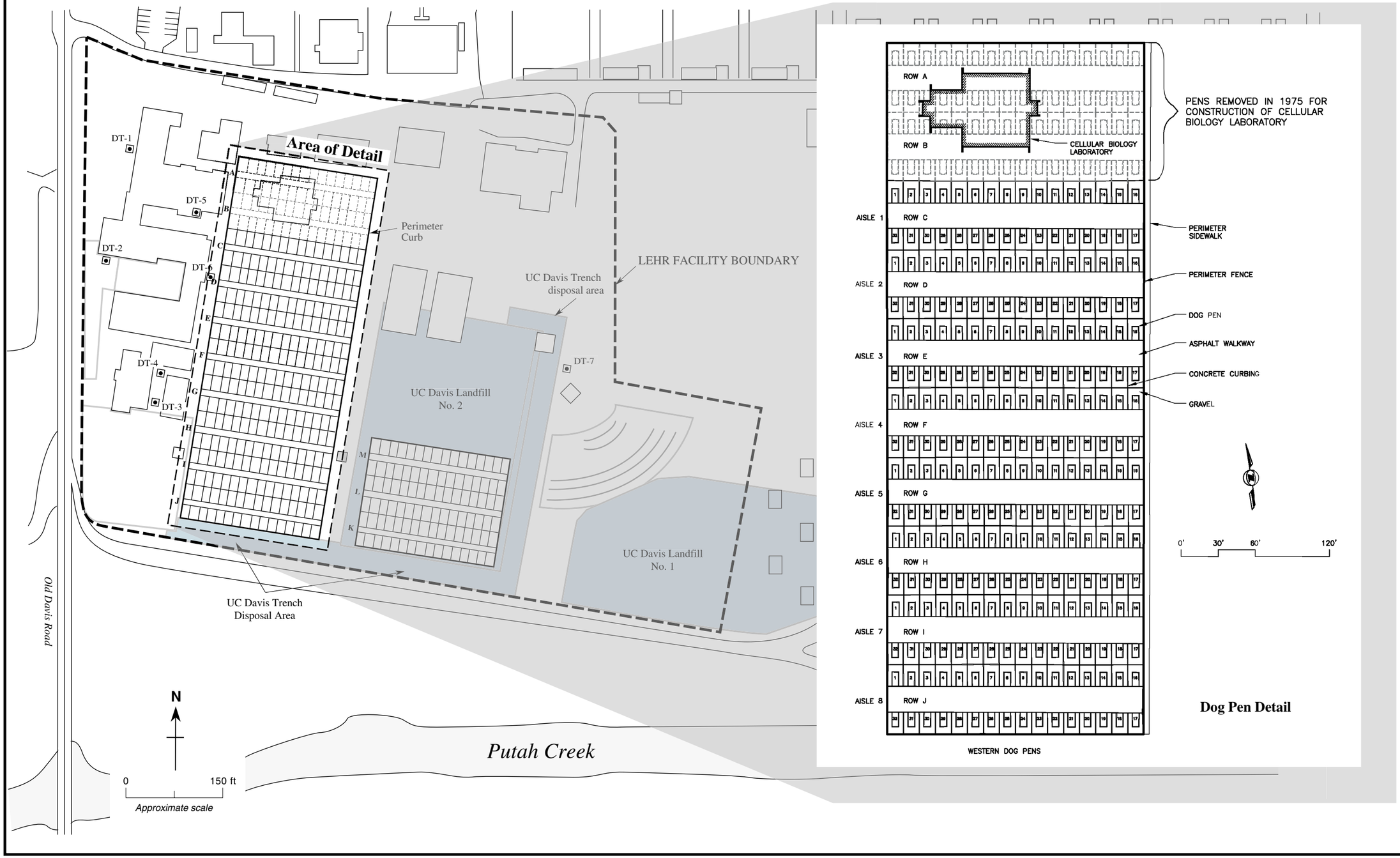

Figure 4-2. Western Dog Pen Features

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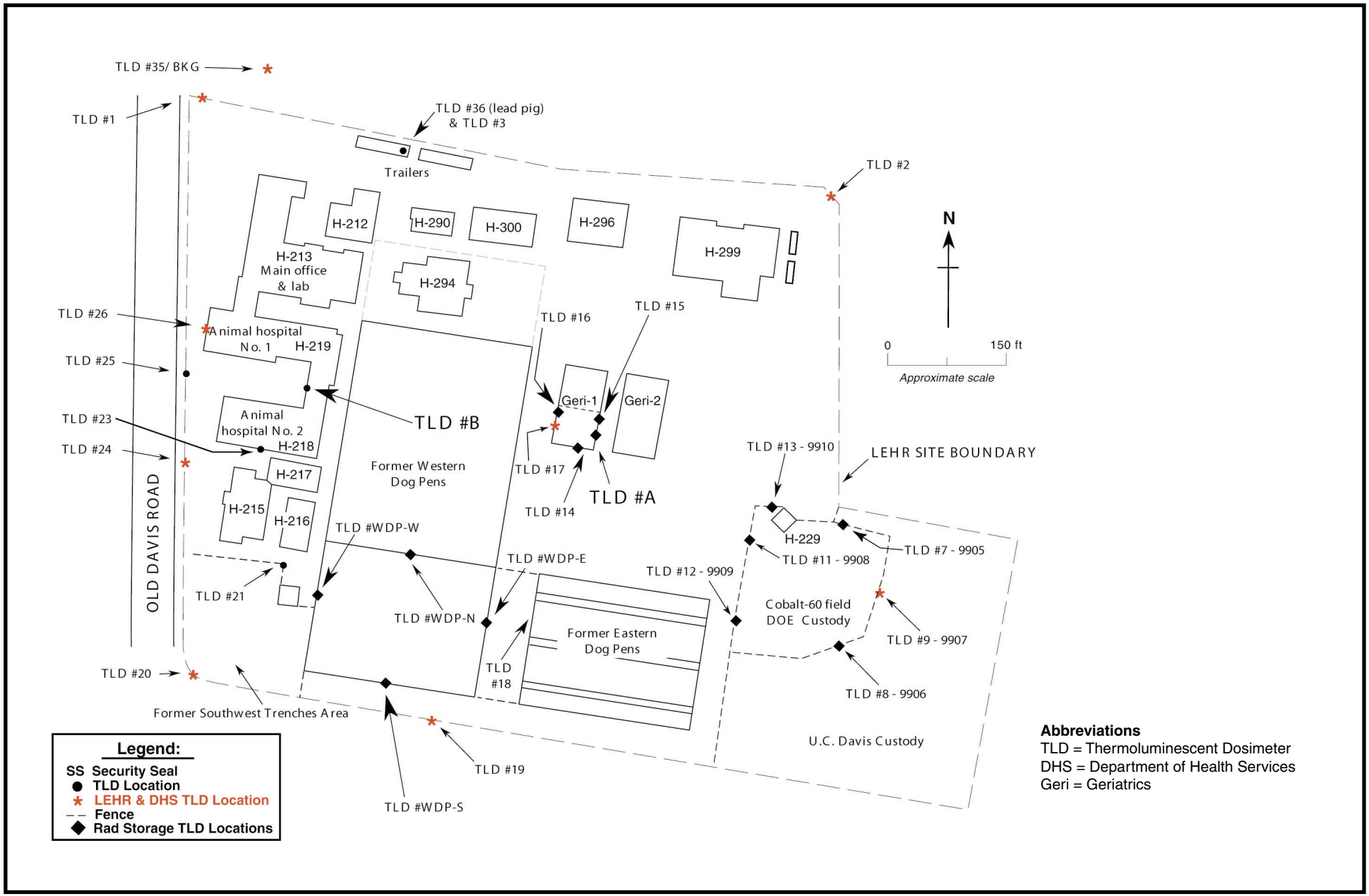

Figure 4-3. Thermoluminescent Dosimeter Location Map, LEHR Site, UC Davis, California

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5. ENVIRONMENTAL NON-RADIOLOGICAL PROGRAM INFORMATION

This section summarizes significant results and trends in 2001 non-radiological LEHR site air, soil and water monitoring.

5.1 Non-Radiological Air Monitoring

Air monitoring for non-radiological compounds was performed to detect potential releases of non-radiological compounds into ambient air resulting from the 2001 Western Dog Pens removal action. Based on the constituents of concern detected in soil in the Western Dog Pens area prior to the 2001 removal action, an air monitoring program for chlordane and particulate matter with aerodynamic size less than or equal to 10 micrometers (PM_{10}) was established for pre-, and post-removal action sampling and for monthly sampling. Table 5-1 presents the average and maximum concentrations, Occupational Safety and Health Administration's permissible exposure limits , preliminary remediation goals, and statistical test results for chlordane, the only constituent with concentrations greater than the detection limit.

Chlordane was detected at a concentration greater than the detection limit in one sample. Statistical tests indicated that the median of the data set was below the preliminary remediation goal and permissible exposure limit ambient air values. The only detected concentration, 0.158 micrograms per cubic meter ($\mu g/m^3$), was above the preliminary remediation goal, but well below the permissible exposure limits.

The EPA specifies a size-specific air quality standard for PM_{10} ambient air particulate (Federal Register, 1987) and has established a screening level for sensitive groups of 150 $\mu g/m^3$ for a 24-hour average exposure period. Above this level, the EPA recommends that sensitive groups, including children, the elderly, and people with heart or lung disease, reduce their exposure.

Air monitoring for PM_{10} was conducted at the site air monitoring stations in 2001 and indicated that PM_{10} concentrations did not exceed the 150 $\mu g/m^3$ EPA standard.

5.2 Non-Radiological Soil Monitoring

5.2.1 Western Dog Pens

Based on statistical evaluation of the Western Dog Pens soil data, all of the soil removed during the Western Dog Pens removal action, except for the Aisle 3 soil, was uncontaminated and returned to the excavation. After completion of the Western Dog Pens removal action, confirmation samples were collected from the Western Dog Pens shallow soil and analyzed for chlordane, mercury and hexavalent chromium.

A total of 38 confirmation samples (including 5 field duplicates) were collected from the Western Dog Pens excavation. Both random-based and discretionary hot spot confirmation samples were collected to ensure attainment of risk-based action standards using a statistically-based sampling design. Twenty-one of the primary sample locations were random-based and 12 locations were discretionary.

Hexavalent chromium concentrations exceeded the California-specific residential preliminary remediation goals in 12 samples and the site-specific background concentration in 26 samples, but were well below the lowest risk-based action standards and industrial preliminary remediation goals. Mercury and total chlordane were detected above background in some samples but were not detected in concentrations greater than any of the applicable standards. One alpha-plus-gamma chlordane result exceeded the risk-based action standard. The 5.1 milligrams per kilogram (mg/kg) maximum reported mercury concentration was detected in a soil sample collected 1.5 feet below ground surface from pen I-22 (Figure 4-2).

Five cobble samples (including one field duplicate) were collected during confirmation sampling. One cobble sample was collected from each of the four east-west oriented trenches at a discretionary location. The soil beneath each of the cobble sample locations was also sampled and analyzed for the full confirmation suite. The 1.17 mg/kg maximum reported hexavalent chromium concentration was detected in a soil sample collected beneath a cobble trench at 2.5 feet below ground surface in pen C-5 (Figure 4-2).

Aisle 3 was the former storage location for chlordane-impacted soil removed during a 1998 Southwest Trenches removal action. Surface soil samples were collected from four random locations and analyzed for chlordane only. Only one of the samples exceeded the lowest risk-based action standard for alpha-plus-gamma chlordane of 800 µg/kg at maximum reported alpha-plus-gamma chlordane and total chlordane concentrations of 873 µg/kg and 2,120 µg/kg, respectively.

Additional samples of Aisle 3 soil were also collected to determine the vertical and lateral extents of chlordane contamination. Two samples collected five feet north of the sample with the maximum reported alpha-plus-gamma chlordane concentration contained an alpha-plus-gamma chlordane concentration at 1,529 µg/kg and a total chlordane concentration of 4,340 µg/kg. All of the other samples collected around the original sample with the elevated concentration were well below the action levels.

The confirmation sample data are evaluated in detail in the Draft Western Dog Pens Area Removal Action Confirmation Report (WA, 2002b). This evaluation included a human health risk analysis based on the site-specific risk-based action standards. The human health risk analysis indicated that the removal action activities reduced the cumulative cancer risk to a nominal range of 10^{-4} to 10^{-6}. The risk analysis determined that the non-cancer Hazard Index was reduced below 1.0.

5.2.2 Domestic Septic System 3

During the 2001 investigation of the domestic septic systems contaminated soil was found at domestic septic systems 3 and 6. At domestic septic system 3, soil samples were collected and analyzed for metals, nitrate, pesticides/polychlorinated biphenyls, semi-volatile organic compounds, volatile organic compounds and hexavalent chromium, the full suite of constituents of concern.

Cadmium, copper, lead, manganese, mercury, and silver were detected above their respective soil background levels for depths greater than four feet below ground surface and lowest risk-based action standard values. Seventeen constituents were detected above their respective preliminary remediation goals for residential soil. The distribution box sediment sample and the soil sample collected beneath the first point of perforation had the maximum reported concentrations for the majority of the detected constituents. The maximum reported mercury concentration, 751 mg/kg, was detected in the distribution box sediment sample. Mercury concentrations in soil ranged from 0.35 mg/kg to 498 mg/kg. There were only five soil samples collected from the domestic septic system 3 area; therefore, the extent of mercury contamination is not fully known. Four semi-volatile organic compounds were reported in concentrations that exceeded their respective lowest risk-based action standard values and preliminary remediation goals for residential soil in one soil sample.

Additional removal action and sampling at Domestic Septic System 3 is being conducted in 2002.

5.2.3 Domestic Septic System 6

Samples were collected and analyzed for a full suite of constituents of concern to characterize domestic septic system 6 area soil. Antimony, barium, copper, lead and mercury were detected above their respective soil background levels for depths greater than four feet below ground surface and lowest risk-based action standard values. Fourteen constituents were detected above their respective preliminary remediation goals for residential soil.

Mercury was detected above background and the lowest risk-based action standards in 31 of 34 samples in concentrations ranging from 0.26 to 101 mg/kg, and was reported in concentrations above the lowest risk-based action standards and residential preliminary remediation goals in samples collected beneath all four leach lines. Based on analytical results, the mercury appears to be limited to the upper seven feet of soil. The lateral extent of contamination has not been fully defined, but should be limited to the areas containing the leach field drain rock and adjacent soil. Five

samples were collected from the sidewalls and floor of the domestic septic system 6 removal action excavation. The mercury concentrations in these samples ranged from 0.13 to 3 mg/kg.

Four semi-volatile organic compounds were detected above their respective lowest risk-based action standards and preliminary remediation goals for residential soil in a two-point composite sample collected beneath the first points of perforation on the northern leach lines.

Hexavalent chromium, at 0.13 mg/kg, was only constituent detected above the lowest site soil backgrounds in a concrete sample from the Domestic Septic Tank 6 tank bottom. However, the hexavalent chromium concentration was well below the lowest risk-based action standard and residential preliminary remediation goal concentration.

Additional removal action and sampling at Domestic Septic System 6 is being conducted in 2002.

5.3 Non-Radiological Surface and Storm Water Monitoring

In 2001, surface water sampling was conducted and reported by UC Davis. Trends and conclusions drawn from the surface and storm water monitoring results are discussed briefly below. A detailed discussion of results and tables summarizing the analytical data can be found in the 2001 Draft Annual Groundwater Treatment System and Water Monitoring Report (URS, 2002).

5.3.1 Surface Water Monitoring

In 2001, UC Davis collected six surface water samples from three locations: PCU, STPO, and PCD (Figure 3-1). Samples were collected during two rainfall events on January 11 and December 20, 2001. Significant findings include:

- volatile organic compounds were not detected in any surface water samples during 2001;
- All total and hexavalent chromium results were below the site contract-required detection limit.
- The levels of nitrate in surface water samples were slightly lower than the range of results observed over the past few years.
- Total dissolved solids concentrations were similar to historical results.
- No evidence of chronic toxicity was indicated in the analyses of site surface water samples, with the exception of the November/December 2001 PCU sample, where pimephales (fish) species mortality was 50%.
- Pesticides and polychlorinated biphenyls were not reported above the contract-required detection limits in surface water samples.

- As in previous years, the following metals were detected at levels above the contract-required detection limits: barium, boron, copper, iron, manganese, molybdenum, selenium, vanadium, and zinc. All results were within historical ranges of detection, except for boron, which was added to the list of metals during the 2000 sampling period.

5.3.2 Storm Water Monitoring

The 2001 storm water monitoring program conducted by UC Davis and DOE consisted of collecting a total of seven samples, including one duplicate sample. DOE collected samples at sample point LS-1 and UC Davis collected samples at LF-1 and LF-3. For each sampling event, a sample was collected from three storm water runoff locations shown on Figure 3-1 (LF-1, LF-3, and LS-1). Grab samples were collected on January 10, 2001 at sample locations LF-1 and LF-3; on January 11, 2001 at sample location LS-1; on November 12, 2001 at LS-1; and December 20, 2001 at LF-1 and LF-3. The January samples represent the 2000/2001 rainy season and the November/December samples represents the 2001/2002 rainy season. All storm water sampling locations were sampled for field parameters, acute aquatic toxicity, metals, nitrate, oil and grease, pesticides and polychlorinated biphenyls, total dissolved solids, total organic carbon, total suspended solids and volatile organic compounds.

Analytical results were similar to previous years. Significant results include:

- Chloroform was not reported above the contract-required detection limit in any storm water samples collected from the Site in 2001, nor in the previous four years. No other volatile organic compound was reported in stormwater samples from either landfill location. Toluene was reported in the January LS-1 sample at 16 micrograms per liter. Toluene has been previously reported in LS-1.
- Concentrations of nitrate as nitrogen were all below 1.5 milligrams per liter (mg/L), consistent with historical trends.
- Total dissolved solids concentrations ranged from 75 to 194 mg/L, which is within historical range.
- Concentrations of total chromium and hexavalent chromium were below the contract-required detection limit in January and above the historical variability for November and December, possibly because the 2001 samples were unfiltered (previous samples were filtered). The highest concentrations were 211 µg/L at LF-3.
- Metals detected above the contract-required detection limits in 2001, included antimony, arsenic, barium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, vanadium, and zinc. As expected, metal levels were higher in the unfiltered samples collected in November/December than in the filtered samples collected in January.

- Three pesticides were detected above the contract-required detection limit: 4,4'-dichlordiphenyl dichlor (0.025 µg/L), alpha chlordane (0.041-0.073 µg/L) and gamma chlordane (0.059-0.094 µg/L). The alpha and gamma chlordane were higher than prior years, whereas the 4,4'- dichlordiphenyl dichlor was within the historical range. The samples were collected at the lift station sampling location (LS-1) (Figure 3-1). The former dog pen areas were a potential source of chlordane contamination and were remediated in 2001. Polychlorinated biphenyls were not detected above the contract-required detection limit.
- Oil and grease, total organic carbon and total suspended solids were within historical ranges.
- Mercury sampling was conducted by DOE at the lift station sampling location LS-1 (Figure 3-1). Mercury was not detected in the January 11, 2001 sample, but was detected at 0.54 µg/L in the November 12, 2001 sample.
- Aquatic toxicity results show no significant adverse effects.

In 1998, the southern portion of the site was covered with shotcrete and now sampling point LF-3 primarily represents runoff from off-site buildings, roads, and agricultural fields. To collect a sample representative of the runoff from Landfill Disposal Unit 3 (Figure 1-2), UC Davis plans to move the LF-3 sampling point to the east-west drainage ditch pipe outfall to the north-south drainage ditch bisecting Landfill Disposal Unit 3.

5.3.3 National Pollutant Discharge Elimination System Data

The Site discharges its sanitary waste to the UC Davis Wastewater Treatment Plant according to National Pollutant Discharge Elimination System permit requirements. Current DOE/NNSA activities do not contribute to hazardous discharges.

Table 5-1. Summary of the Western Dog Pens Removal Action Air Monitoring Data

Contaminant of Concern	Average Concentration ($\mu g/m^3$)	Maximum Concentration ($\mu g/m^3$)	PRG ($\mu g/m^3$)	PEL ($\mu g/m^3$)
Pesticides				
Chlordane	N/A	0.158	0.019	500

Abbreviations
N/A not applicable
PEL permissible exposure limit
PRG preliminary remediation goal for ambient air
$\mu g/m^3$ micrograms per cubic meter

6. SITE HYDROLOGY, GROUND WATER MONITORING AND PUBLIC DRINKING WATER PROTECTION PROGRAM

Ground water monitoring has been conducted at the Site since November 1990. Quarterly monitoring began as a component of the Phase II Site Characterization (Dames & Moore 1993). In 1993, a Site water monitoring plan was developed to meet the requirements of DOE's General Environmental Protection Program under DOE Order 5400.1. In 1997, a Memorandum of Agreement between DOE and UC Davis transferred responsibility for ground water sampling from DOE to UC Davis. The ground water monitoring program discussed in this section is the responsibility of UC Davis. In 1998 UC Davis began operating and monitoring a ground water interim remedial action system to reduce off-site migration of volatile organic compounds, primarily chloroform. In 1999, quarterly monitoring began as part of the site Remedial Investigation focusing on six constituents of concern: volatile organic compounds (primarily chloroform), hexavalent chromium, nitrate, total dissolved solids, tritium and carbon-14. The monitoring data were included in a Draft Remedial Investigation submitted to the U.S. EPA in March 2002 (WA, 2002c).

In 2001 all ground water monitoring at the Site was performed and reported by UC Davis. The results of the water monitoring are summarized briefly here, and are discussed in detail in the UC Davis Quarterly Water Monitoring Reports and the Draft 2001 Annual Groundwater Treatment System and Water Monitoring Report (URS, 2002). Figure 3-1 shows the location of LEHR ground water monitoring wells.

6.1 Uses of Ground Water in the LEHR Vicinity

As discussed in Sections 1.4.2 and 1.4.3, local ground water is utilized for both drinking and agricultural purposes. The major ground water sources for both public and private water supplies in the Sacramento Valley are unconsolidated deposits of Pliocene and Pleistocene age, and older alluvium (DOE, 1992b). Water from the first HSU is not used for drinking or irrigating purposes due to inadequate yield. A number of domestic and irrigation wells in the site vicinity produce water from HSU-2.

6.2 Potential Sources of Ground Water Pollution

Most impacts to ground water that have been identified are localized at the Site near waste burial locations and are within the first HSU, which is not used for drinking water.

6.3 Ground Water Monitoring

The ground water monitoring program and the 2001 sampling results are summarized below and discussed in detail in UC Davis' Draft 2001 Annual Groundwater Treatment System and Water Monitoring Report (URS, 2002). Ground water monitoring data is presented herein in Tables 6-1 and 6-2. Isoconcentration maps for HSU-1 and HSU-2 are included in Appendix A.

As part of the ground water monitoring program, 24 wells are sampled quarterly and six additional wells are sampled annually in spring (May) when ground water levels are typically higher. A total of 113 samples, including 11 duplicates, were collected from the 30 monitoring wells in 2001.

Two radiological constituents of concern are monitored in all ground water monitoring wells: carbon-14 and tritium. Other radionuclides were monitored in the two newest wells, UCD2-46 and UCD4-47, for the first two quarters. Four samples from these wells were analyzed for the full suite of 22 radionuclide analytes (gross alpha and beta, tritium, carbon-14, strontium-90, radium-226, americium-241, plutonium-241, thorium-234, lead-214, bismuth-214, lead-210, uranium-235, uranium-238, sodium-22, actinium-228, lead-212, bismuth-212, thalium-208, potassium-40, cobalt-60 and cesium-137).

UC Davis operates an interim remedial action treatment system to control and reduce ground water contamination at the Site. Monitoring of the system is conducted by UC Davis to assess the effect of the interim remedial action treatment system on the contaminant plume. Two major treatment system modifications were initiated at the end of 2000 that kept the system inoperative during much of 2001. Monitoring of 17 interim remedial action wells during this time showed that throughout the system shutdown necessitated by system modifications and technical problems, mass removal of chloroform was reduced to approximately 5 pounds or 20% of the 1999 and 2000 levels.

In addition to the ongoing interim remedial action monitoring programs, a density-driven convection pilot test system was installed in December 2000 (URS, 2002) to assess removal of chloroform and other volatile organic compounds in the plume source area. This system was installed in the vicinity of UCD1-12 (Figure 3-1). Sampling of the density-driven convection pilot test system was conducted in 2000 and 2001.

6.3.1 Monitoring Results for Radionuclides

In 1999, a removal action was conducted by UC Davis at the Waste Burial Holes (Figure 1-2) to remove the sources of carbon-14 and tritium. At the end of 2001, HSU-2 wells downgradient of this source area indicated decreased contaminant concentrations. As in previous years, tritium has been consistently reported in only two wells, UCD1-13 and UCD2-14, and sporadic low tritium concentrations have been reported in other site wells. The majority of the 22 radionuclides monitored in two new HSU-2 wells, UCD2-46 and UCD4-47, were below the minimum detectable activity. Detected radionuclides were just slightly above the contract-required detection limits.

Ground water monitoring results for 2001 for radionuclides are summarized below by HSU.

HSU-1: HSU-1 wells were only monitored for carbon-14 and tritium. Carbon-14 was detected in two of the five HSU-1 wells sampled in 2001. Carbon-14 activity was lower than in recent years and ranged from 21.1 ±9.57 pCi/L in UCD1-12 to 1,160 ±23.6 pCi/L in UCD1-13. Tritium was only detected in one HSU-1 well, UCD1-13, of the five HSU-1 wells sampled in 2001 and UCD1-13 is sampled on an annual basis. Tritium activity in UCD1-13 was 12,200 ±395 pCi/L, which is consistent with typical activity in that well.

HSU-2: Since site ground water monitoring began, carbon-14 has been consistently detected in UCD2-14 near the Waste Burial Holes at activities averaging 500 pCi/L. During 2001, carbon-14 in UCD2-14 was detected between 77.7 ±7.62 pCi/L (November 2001) and 576 ±15.1 pCi/L (May 2001). Carbon-14 activity is generally lower during the winter sampling of this well. Carbon-14 was also detected in four other HSU-2 wells, UCD2-29, UCD2-30, UCD2-39 and UCD2-45, ranging from 12.5 ± 3.53 pCi/L to 17.6 ±5.53 pCi/L.

Tritium was detected in three HSU-2 wells, UCD2-14, UCD-16 and UCD2-35, ranging from 420 ±128 pCi/L in well UCD2-16 to 4,720 ±296 pCi/L in well UCD2-14. These activities are within historical ranges for these wells.

HSU-4: In 2001, neither carbon-14 nor tritium was detected in HSU-4 wells in concentrations above the contract-required detection limit.

6.3.2 Non-Radionuclides

Ground water monitoring results for 2001 for non-radionuclides are summarized below by HSU.

HSU-1: During 2001, chloroform was detected above the 0.5 µg/L contract-required detection limit in four of seven HSU-1 wells monitored. Chloroform ranged from 1.0 to 49.7 µg/L. Chloroform concentrations declined in the volatile organic compound source area due to the DDC pilot test system. Other than chloroform, no other volatile organic compounds were detected above the contract-required detection limits in HSU-1 wells during 2001.

HSU-1 contained the highest chromium concentrations in 2001, consistent with previous monitoring. Chromium was detected up to 594 µg/L in HSU-1 well UCD1-28. Reported concentrations of nitrate were almost all within the range of previous results for each well in HSU-1. The highest nitrate concentration for site wells in 2001 was 77.8 mg/L in UCD1-12. UCD1-28 was monitored for total organic carbon, with results ranging from 1.77 to 6.25 mg/L, which is within the historical range. HSU-1 was not monitored for other metals in 2001.

HSU-2: Of the 18 HSU-2 wells monitored in 2001, eight wells contained no non-radionuclides above the contract-required detection limits. As in prior years, the highest concentration of chloroform for site wells in HSU-2 was reported in UCD2-29 at 206 µg/L. Six

other volatile organic compounds were detected in HSU-2 wells, 1,1-dichloroethane, 1,1-dichloroethene, 1,2dicholorethane, 1,2-dichloropropane, and tetrachloroethene. HSU-2 wells, UCD2-29 and UCD2-30 contained 1,1-dichloroethane up to 0.62 µg/L, 1,2-dichloroethane up to 0.82 µg/L, and 1,2-dichloropropane up to 0.97 µg/L. UCD2-29 also contained 1,1-dichloroethene up to 0.89 µg/L. Chloromethane was detected in wells UCD2-38 at 1.1 µg/L, UCD2-39 at 0.94 µg/L, and UCD2-40 at 0.83 µg/L. Tetrachloroethene was reported above the contract-required detection limit in one sample from UCD2-31 at 1.4 µg/L. One semi-volatile organic compound, napthlene was detected in HSU-2 well UCD2-46 at 1.2 µg/L. Concentrations of chromium, nitrate and metals were consistent with those for prior years.

HSU-4: Four of the five HSU-4 wells had measurable levels of chloroform with concentrations similar to results in recent years, ranging from 0.57 µg/L to 5.7 µg/L. UCD4-44, installed three years ago to help determine whether HSU-4 was impacted by site constituents upgradient from the abandoned agricultural well 22N, contained no chloroform in 2001. Chromium concentrations in HSU-4 wells in 2001 were consistent with those reported since sampling began, ranging from 18.7 µg/L to 38.7 µg/L. Nitrate detections were also consistent with prior year's results, ranging from 1.78µg/L to 7.6 µg/L. Metals samples were collected from only one HSU-4 well (UCD4-47), and the results were similar to those reported in 2000. Arsenic and vanadium were reported in one sample just above the contract-required detection limit, at 3.02 µg/L and 10.9 µg/L, respectively.

6.4 Off-Site Supply Well Sampling

Private wells south, north, and east of the Site have been sampled since 1989. Because these wells are not consistently constructed, limited comparisons cannot be made between these wells and those at the site. The off-site supply well sampling program has provided information about the primary site constituents of concern: volatile organic compounds, tritium, hexavalent chromium, nitrate as nitrogen, gross alpha and gross beta. Monitoring of radiological constituents in private wells ceased in 1996 because no radiological contamination that could be attributed to the LEHR Site was found in any off-site supply well.

In 2001, UC Davis sampled irrigation and domestic wells east and south of the Site three times (spring, summer and fall) (Figure 6-1). Nitrate as nitrogen was detected in seven of the sixteen wells sampled. Hexavalent chromium was detected in many of the wells sampled. These compounds are present in regional ground water, and no direct link to the Site has been established.

In 2001, the only VOC found above the detection limit in off-site private wells was 1,1-Dichloroethylene. It was detected in concentrations from 3.2 to 5.7 µg/L in the summer samples collected from off-site wells, NJIW (22J), RDW, MDW, MIW (28C). 1,1-Dichloroethylene was not detected in the same wells in subsequent samples collected during the fall of 2001. All of the summer sample results were below the EPA Maximum Contaminant Level for drinking water for 1,1-Dichloroethylene of 6 µg/L. Based on the 1,1-Dichloroethylene concentrations observed in the

LEHR site wells (maximum 0.89 μg/L) the concentrations found in the off-site wells do not appear to be attributed to the LEHR site.

Table 6-1. Summary of LEHR Site-Wide Ground Water Monitoring Program for Calendar Year 2001

	Remediation[1]
Number of active wells monitored	30
Number of samples taken	200
Number of analyses performed	1,400
Percent of analyses below detection limits	88%

Notes

[1] Ground water monitoring at LEHR is performed for remediation purposes only.

Table 6-2. Ranges of Results for Ground Water Monitoring Positive Detections[1]

Analyte	Concentration Range
1,1-Dichloroethane	0.57 – 0.62 µg/L
1,1-Dichloroethene	0.67 – 0.89 µg/L
1,2-Dichloroethane	0.56 – 1.0 µg/L
1,2-Dichloropropane	0.52 – 0.97 µg/L
Alkalinity, total as $CaCo_3$	387-502 mg/L
Aluminum	2.63 µg/L
Arsenic	3.02-3.38 µg/L
Barium	88.2 – 180 µg/L
Beryllium	0.19 µg/L
Bismuth-214	4.02 – 19.5 pCi/L
Boron	718-1,120µg/L
Calcium	40,800-57,200 µg/L
Carbon-14	6.72- 1,160 pCi/L
Chloride	24.3-36.1 mg/L
Chloroform	0.54 – 206 µg/L
Chloromethane	0.83 – 1.1 µg/L
Chromium	6.2-594 µg/L
Cobalt	0.19 - 0.264 µg/L
Copper	1.75- 1.9 µg/L
Gross Alpha	2.12-4.13 pCi/L
Gross Beta	2.13- 3.42 pCi/L
Lead-214	13.9 – 16.7 pCi/L
Magnesium	69,600-94,700 µg/L
Manganese	0.355 µg/L
Molybdenum	1.39- 1.74 µg/L
Naphthalene	0.60- 1.2 µg/L

Table 6-2. Ranges of Results for Ground Water Monitoring Positive Detections (continued)

Analyte	Concentration Range
Nickel	1.33 - 1.51 µg/L
Nitrate (as Nitrogen)	1.46- 77.8 mg/L
Potassium	1,130-2,060 µg/L
Potassium-40	32.9 pCi/L
Radium-226	0.407 – 3.32 pCi/L
Selenium	4.27 – 9.49 µg/L
Sodium	59,400- 84,700 µg/L
Sulfate as S_{O4}	43.4 - 65.3 mg/L
Tetrachloroethene	0.25 - 1.4 µg/L
Thallium	0.334 - 0.644 µg/L
Total Dissolved Solids	400- 2,260 mg/L
Total Organic Carbon	0.920 – 6.25 mg/L
Tritium	201- 12,200 pCi/L
Vanadium	10.8 – 10.9 µg/L

Notes

1. All results for positive detections are for samples collected for the purposes of remediation monitoring.

Abbreviations

µg/L micrograms per liter
CaC_{O3} calcium carbonate
mg/L milligrams per liter
pCi/L picoCuries per liter
SO_4 sulfate

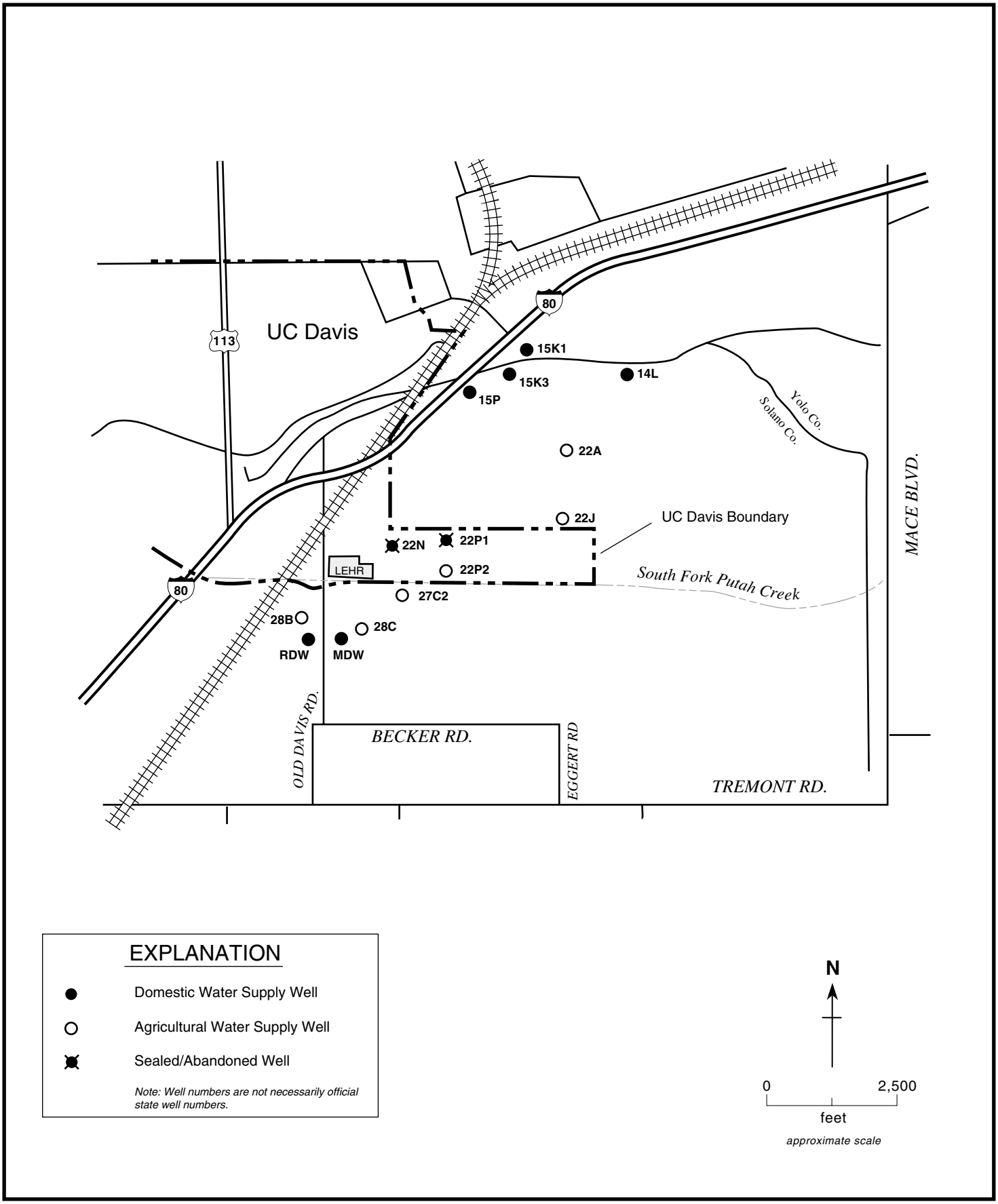

Figure 6-1. Neighbor Well Sampling Program Locations Near the LEHR Site

Weiss Associates

7. QUALITY ASSURANCE

Quality assurance is a key element of the environmental protection program for the Site. A Quality Assurance Project Plan (WA, 2000a) that describes the requirements for all quality-related work on the LEHR project has been prepared and is fully implemented. The Quality Assurance Project Plan and other quality-assuring documents, such as standard quality procedures, standard operating procedures and task-specific work plans, govern all phases of the LEHR program, including site characterization, investigation, risk assessments, decontamination and decommissioning, waste management and site restoration. The purpose of the Quality Assurance Project Plan and these other documents is to identify the specifications and methods employed to establish technical accuracy, precision and validity of measurements and statistics, and to provide a sound basis for management decisions based on environmental information collected for the Site. The Quality Assurance Project Plan for the LEHR Project was prepared in accordance with EPA QA/R-5 (EPA, 2001) and National Quality Assurance specifications. It also conforms to DOE Order 414.4a, the Nuclear Safety Management Quality Assurance Requirements in Title 10 of the Code of Federal Regulations, Section 830.120, and incorporates requirements of DOE Order 5400.1, General Environmental Protection, to ensure that DOE quality and environmental goals are met.

Environmental samples collected by DOE/NNSA that are discussed in this report were collected, analyzed, reviewed and validated according to the Quality Assurance Project Plan and other relevant Standard Operating Procedures and/or task-specific work plans. To assure quality, quality control is integrated into all aspects of environmental sampling. Included in the Quality Assurance Project Plan and related documents are sections identifying quality control for sample collection requirements and specific quality assurance objectives for the measurement data. Quality control samples are run with each sample batch at the analytical laboratory to validate the method of analysis and the proficiency of the analyst. Because holding times are important to the sample quality, they are carefully controlled. To ensure comparability of analytical data, all samples are analyzed by EPA-approved methods when available. When analytic results are received, they are reviewed according to the appropriate data quality objectives and data review procedures. All of the 2001 Site air, soil, and water monitoring data have been presented in other reports. The specific review and validation process for each data set is presented in these reports, and are not discussed in detail here.

7.1 Field Quality Assurance

Quality assurance for field sampling is accomplished by collecting field duplicates, decontamination rinseates, trip blanks and field blanks, as appropriate. For each round of sampling, duplicate samples are collected from a selected sample point at the same location as the original sample to check for consistency in the sampling process. The duplicate sample serves as a check on

the precision of the sampling and analytical procedures. Decontamination rinseates are analyzed whenever the potential exists for cross-contamination from sampling equipment. Trip blanks are sent with each shipment of water samples requiring analysis for volatile compounds. Field blanks are collected to check for contamination during the water sampling process. Calibration records for each field instrument are maintained in the project files.

7.2 Laboratory Quality Assurance

Contracted laboratories providing analytical services for the LEHR Project are evaluated by WA or UC Davis to ensure compliance with the quality assurance program requirements. Laboratory QUALITY ASSURANCE is analyzed externally by submitting split samples, spiked samples, and blanks to the laboratories analyzing environmental samples. Laboratories must submit their analytical procedure for review if it differs from standard procedures. Each contract laboratory is required to maintain participation, as applicable, in DOE, State of California, and/or EPA approved inter-laboratory quality assurance programs such as DOE's Environmental Measurement Laboratory Inter-Laboratory Comparison Program or EPA's Water Pollution/Water Supply Program.

7.3 Compliance Audits

Aspects of the LEHR program are audited periodically to ensure compliance with project standards. Several health and safety and quality assurance audits or surveillances with an Integrated Safety Management System component, and a Radiation Protection Program audit were performed in 2001. All findings and observations identified during the audits have been, or will be, resolved.

7.4 Summary of Quality Control Data Validation

The overall LEHR quality assurance objective is to collect and analyze environmental samples from the Site in a manner that ensures technical data are accurate and representative, are able to withstand scientific and legal scrutiny, and are useful for evaluating site conditions and remedial actions. The criteria used to specify quality assurance goals are precision, accuracy, representativeness, completeness and comparability for evaluation of quality control data. These parameters are evaluated through data validation. Table 7-1 summarizes the components used to monitor and evaluate the quality of LEHR environmental data.

Table 7-1. Components of the LEHR Quality Control Program in Support of Data Quality Objectives

Data Quality Objective	Quality Control Component	Evaluation Criteria
Precision	• Field duplicate • Matrix spike • Matrix spike duplicate	Relative percent difference
Accuracy	• Matrix spike • Matrix spike duplicate • Surrogate spikes	Percent recovery
Representativeness	• Trip blanks • Field duplicate • Method blanks	Qualitative degree of confidence
Completeness	• Holding time • Valid data points	Percent valid data
Comparability	• Analytical methods • Field duplicates	Qualitative degree of confidence

8. DEFINITIONS[1]

Term	Definition
absorbed dose	The energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest in that material. The absorbed dose is expressed in units of rad (or gray) (1 rad = 0.01 gray).
as low as reasonably achievable (ALARA)	A phrase (acronym) used to describe an approach to radiation protection to control or manage exposures (both individual and collective to the work force and the general public) and releases of radioactive material to the environment as low as social, technical, economic, practical, and public policy considerations permit. As used in United States Department of Energy (DOE) Order 5400.5, ALARA is not a dose limit, but rather it is a process that has as its objective the attainment of dose levels as far below the applicable limits of the Order as practicable.
collective dose equivalent and collective effective dose equivalent	The sums of the dose equivalents or effective dose equivalents of all individuals in an exposed population within an 80-kilometer (km) radius, for the purposes of DOE Order 5400.5, and they are expressed in units of person-Roentgen equivalent, man (rem), (or person-sievert). When the collective dose equivalent of interest is for a specific organ, the units would be organ-rem (or organ-sievert). For purposes of DOE Order 5400.5, the 80-km distance shall be measured from a point located centrally with respect to major facilities or DOE program activities.
committed dose equivalent	The predicted total dose equivalent to a tissue or organ over a 50-year period after a known intake of a radionuclide into the body. It does not include contributions from external dose. Committed dose equivalent is expressed in units of rem (or sievert).

[1] Definitions are adapted from Department of Energy Order 5400.5, and United States Environmental Protection Agency.

Term	Definition
committed effective dose equivalent	The sum of the committed dose equivalents to various tissues in the body, each multiplied by the appropriate weighting factor. Committed effective dose equivalent is expressed in units of rem (or sievert).
confirmation suite	Analysis for metals, nitrate, pesticides/polychlorinated biphenyls, semi-volatile organic compounds, volatile organic compounds and hexavalent chromium.
derived concentration guide	The concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode (i.e., ingestion of water, submersion in air, or inhalation), would result in an effective dose equivalent of 100 millirem (1 millisievert). Derived Concentration Guides do not consider decay products when the parent radionuclide is the cause of the exposure (Derived Concentration Guide values are presented in Chapter III of DOE Order 5400.5).
dose equivalent	The product of absorbed dose in rad (or gray) in tissue and a quality factor. Dose equivalent is expressed in units of rem (or sievert).
effective dose equivalent	The summation of the products of the dose equivalent received by specified tissues of the body and a tissue-specific weighting factor. This sum is a risk-equivalent value and can be used to estimate the health-effects risk of the exposed individual. The tissue-specific weighting factor represents the fraction of the total health risk resulting from uniform whole-body irradiation that would be contributed by that particular tissue. The effective dose equivalent includes the committed effective dose equivalent from internal deposition of radionuclides and the effective dose equivalent due to penetrating radiation from sources external to the body. Effective dose equivalent is expressed in units of rem (or sievert).
effluent monitoring	The collection and analysis of samples or measurements of liquid and gaseous effluents for purposes of characterizing and quantifying contaminants, assessing radiation exposures of members of the public, and demonstrating compliance with applicable standards.

Term	Definition
environmental surveillance	The collection and analysis of samples of air, water, soil, foodstuffs, biota, and other media from DOE sites and their environs, and the measurement of external radiation for purposes of demonstrating compliance with applicable standards, assessing radiation exposures of members of the public, and assessing effects, if any, on the local environment.
hazard index	The health impact of the non-carcinogenic compounds is quantified through the hazard index, which is the ratio of the expected concentration of a compound to the acceptable concentration of the compound. When more than one toxic compound is emitted, the hazard indices of the compounds are summed to give the total hazard index. A total hazard index of 1.0 or less is considered to be not significant and the resulting impact on public health is deemed acceptable.
maximally exposed individual	The maximally exposed individual is the representative member of the public who receives the highest estimated effective dose equivalent based on the sum of the individual pathway doses.
members of the public	Persons who are not occupationally associated with a DOE facility or operations (i.e., persons whose assigned occupational duties do not require them to enter the DOE site). Also see: public dose.
preliminary remediation goal (PRG)	Initial clean-up goals that (1) are protective of human health and the environment and (2) comply with applicable or relevant and appropriate requirements. Preliminary remediation goals are developed early in the remedy selection process based on readily available information and are modified to reflect results of the baseline risk assessment. They also are used during analysis of remedial alternatives in the remedial investigation/feasibility study.
public dose	The dose received by member(s) of the public from exposure to radiation and to radioactive material released by a DOE facility or operation, whether the exposure is within a DOE site boundary or off site. It does not include dose received from occupational exposures, doses received from naturally occurring "background" radiation, doses received as a patient from medical practices, or doses received from consumer products.

Term	Definition
quality factor	The principal modifying factor used to regulate the dose equivalent from the absorbed dose. For the purposes of DOE Order 5400.5, quality factors taken from DOE Order 5480.11 are to be used.
radioactivity	Property or characteristic of radioactive material to spontaneously "disintegrate" with the emission of energy in the form of radiation. The unit of radioactivity is the curie (or becquerel).
reference man	A hypothetical aggregation of human (male and female) physical and physiological characteristics arrived at by international consensus (International Council for Radiation Protection Publication 23). These characteristics may be used by researchers and public health workers to standardize results of experiments and to relate biological effects from ionizing radiation to a common base. The "reference man" is assumed to inhale 8,400 cubic meters of air in a year and to ingest 730 liters of water in a year.
remedial action	Those actions consistent with permanent remedy taken instead of, or in addition to, removal action in the event of a release or threatened release of a hazardous substance into the environment, to prevent or minimize the release of hazardous substances so that they do not migrate to cause substantial danger to present or future public health or welfare or the environment.
residual radioactive material	Any radioactive material which is in or on soil, air, equipment, or structures as a consequence of past operations or activities.
RESRAD	Residual Radioactivity model. Argonne National Laboratory computer model for evaluating radioactively contaminated sites. (Argonne National Laboratory)

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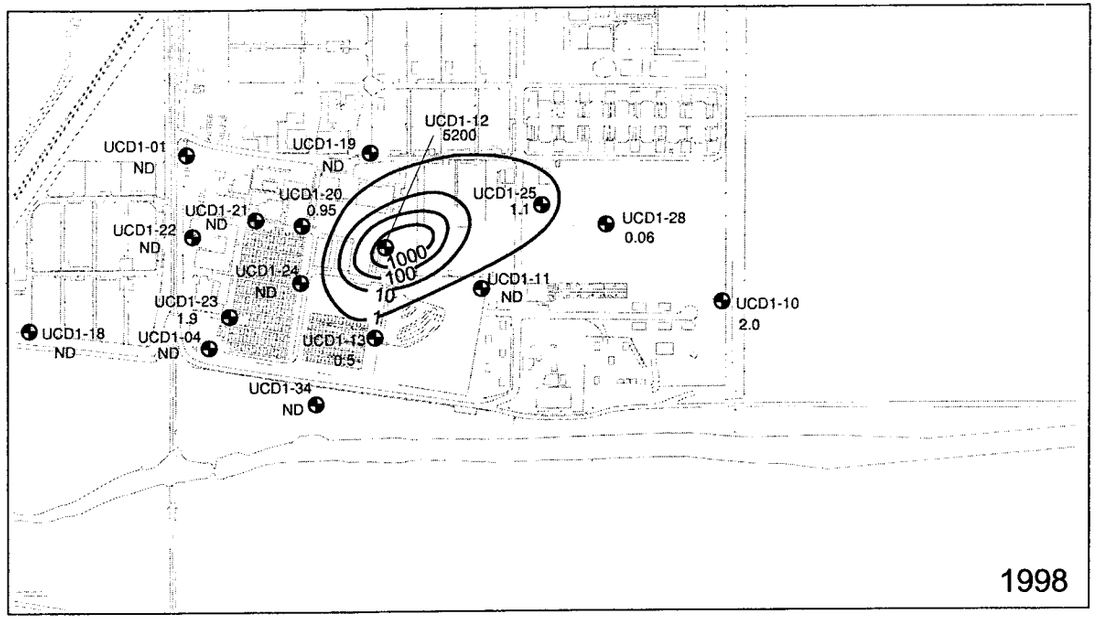
10. ACKNOWLEDGMENTS

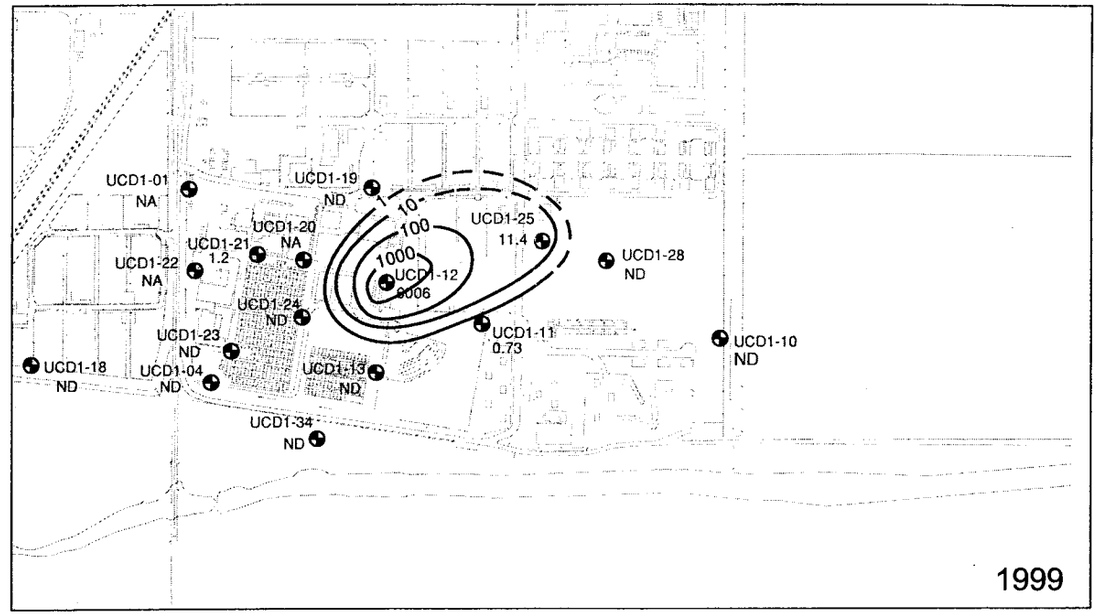
The following LEHR Project personnel worked on the 2001 ASER:

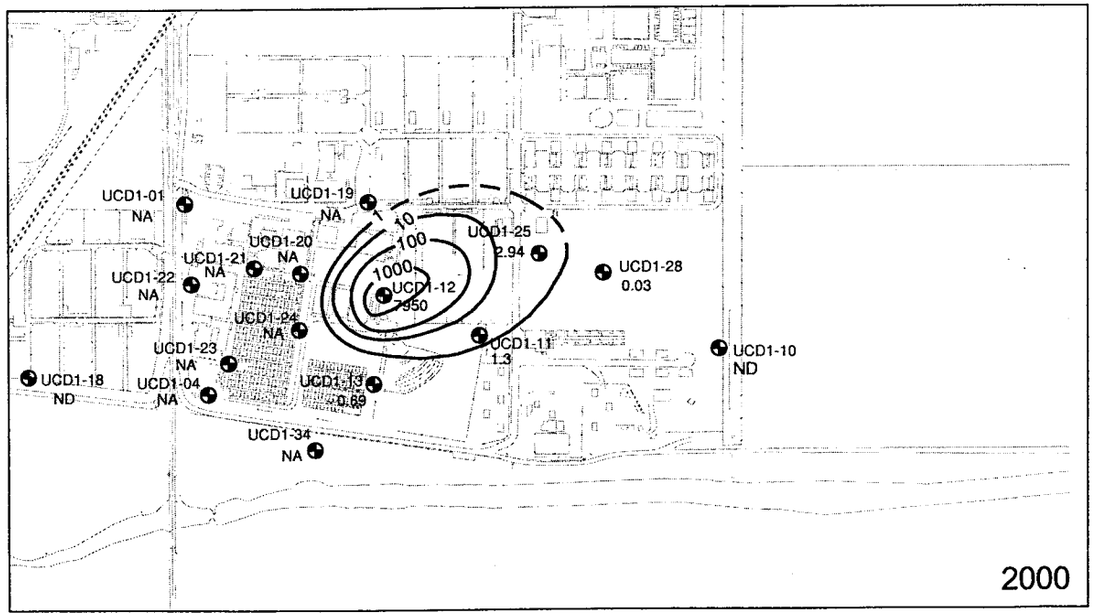
Name and Position	Responsibility
Michael Dresen LEHR Program Manager, Weiss Associates	Senior guidance, review, and quality assurance
Robert Devany LEHR Project Manager, Weiss Associates	Project management, technical guidance and review
Agata Sulczynski, LEHR Regulatory Compliance Manager, Weiss Associates	Report preparation
Joyce Adams Geologist, Weiss Associates	Ground water data interpretation and review
Dolores Loll LEHR Quality Assurance, Weiss Associates	Technical review and quality assurance
Craig Adams Graphics, Weiss Associates	Graphics
Nerissa de Jesus Project Administrator, Weiss Associates	Word processing and report coordination
Ted Trammel Production Personnel, Weiss Associates	Graphics and report production

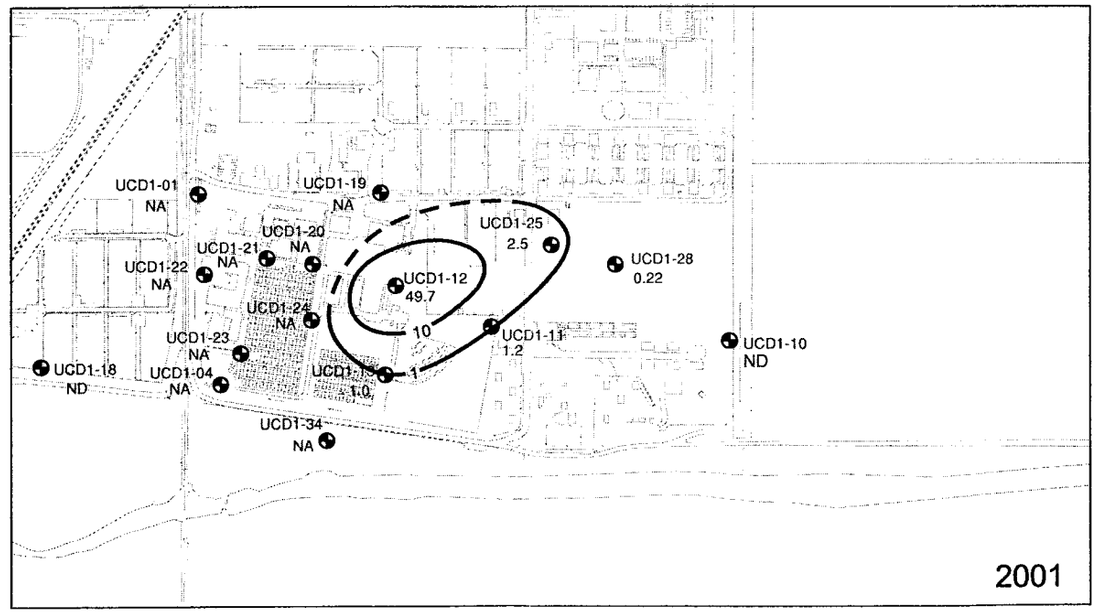
APPENDIX A

ISOCONCENTRATION MAPS
FOR HYDROSTRATIGRAPHIC UNITS 1 AND 2
FROM URS (2002)









LEGEND

- UCD2-17 HSU-2 Monitoring Well
- All results reported in pCi/L
- Results represent average of quarterly data
- NA = Not Analyzed
- ND = Not Detected

CHLOROFORM ISOCONCENTRATION CONTOURS IN HSU-1, 1998 THROUGH 2001

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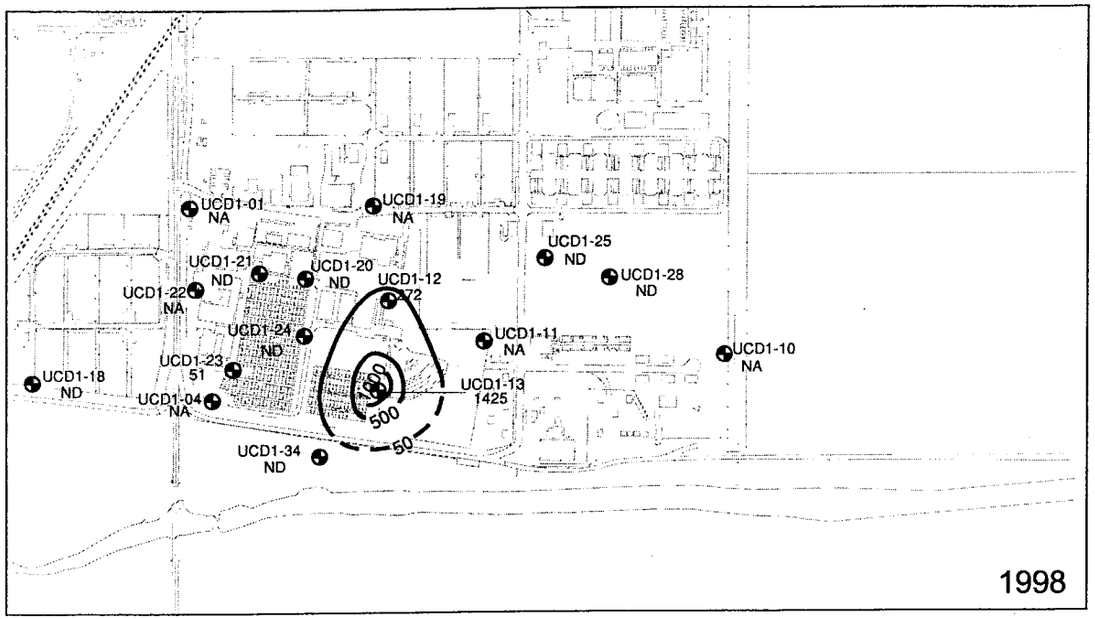

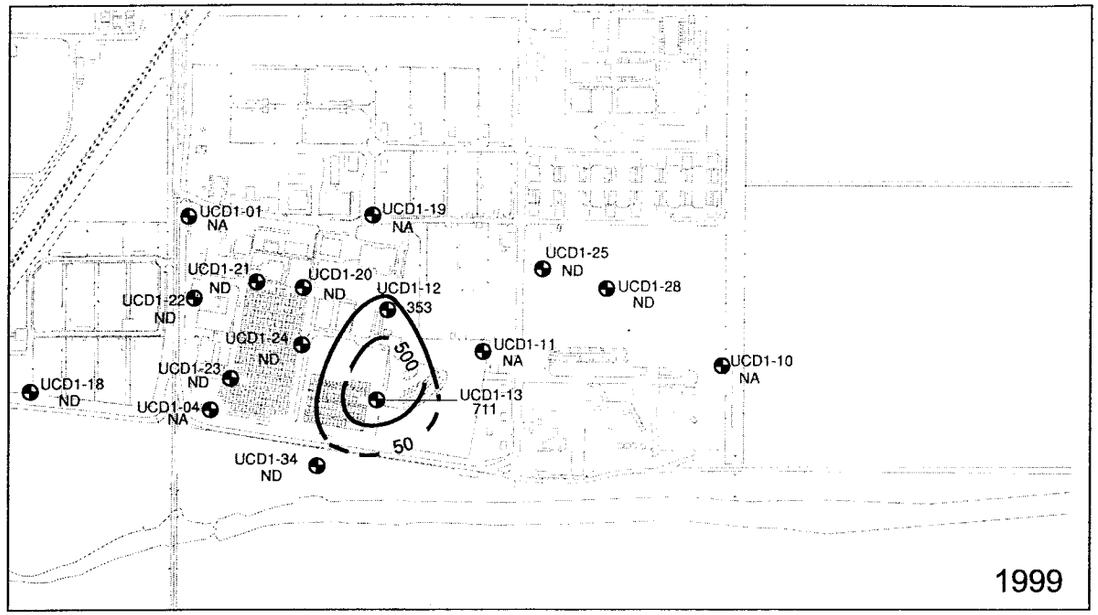

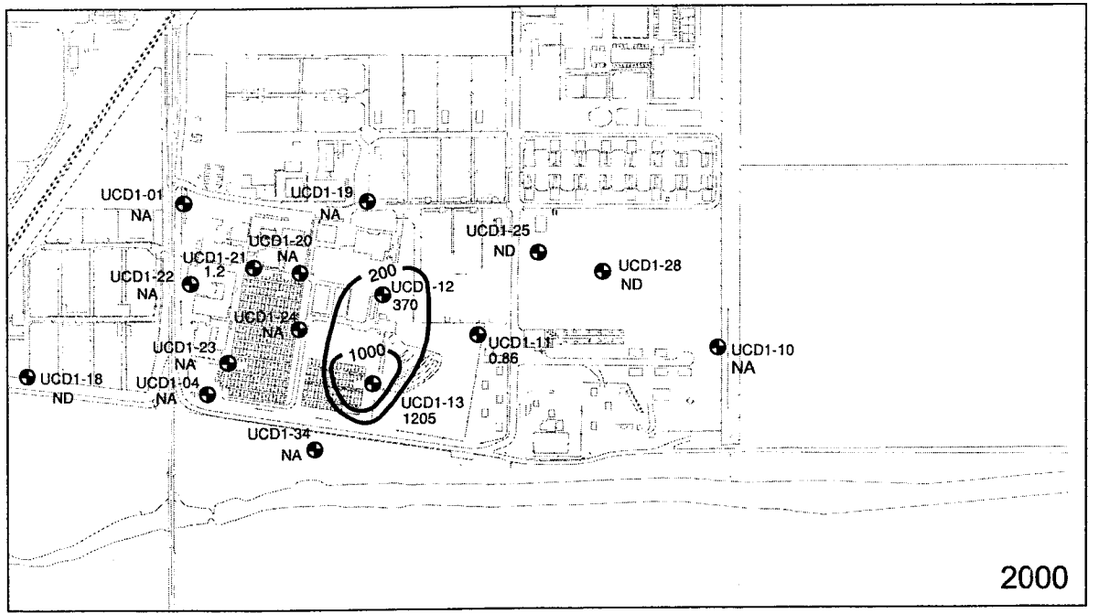

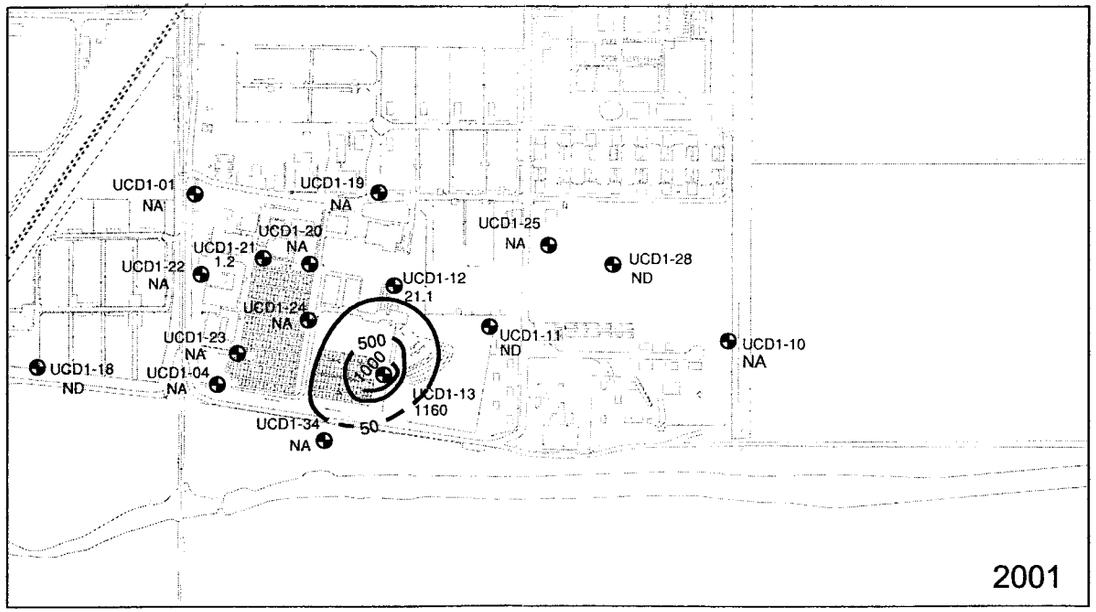

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CARBON-14 ISOCONCENTRATION CONTOURS IN HSU-1, 1998 THROUGH 2001

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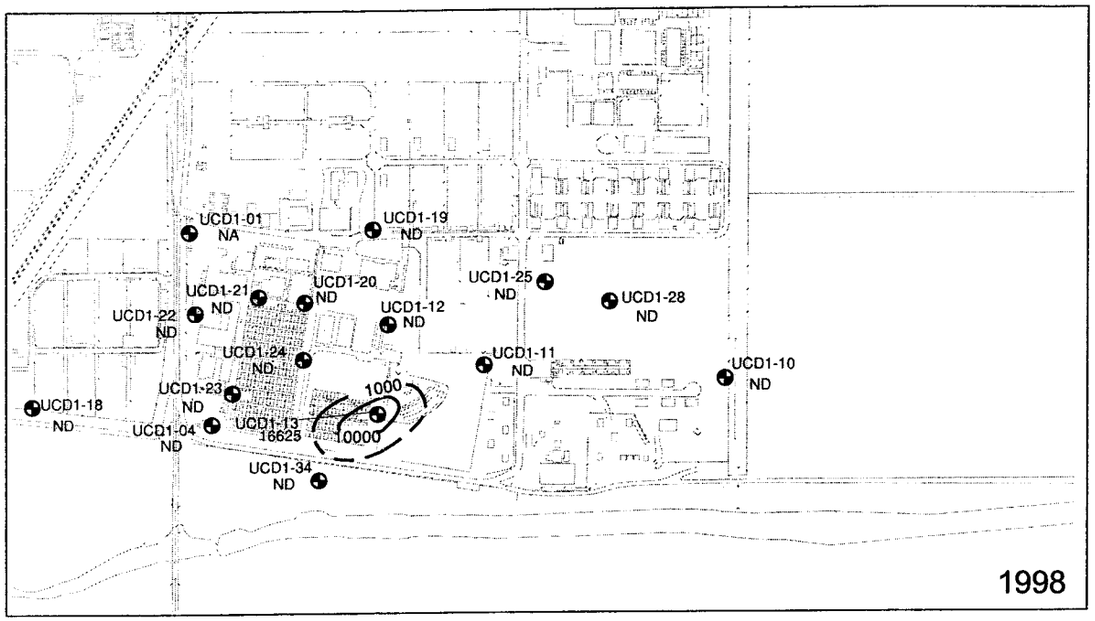

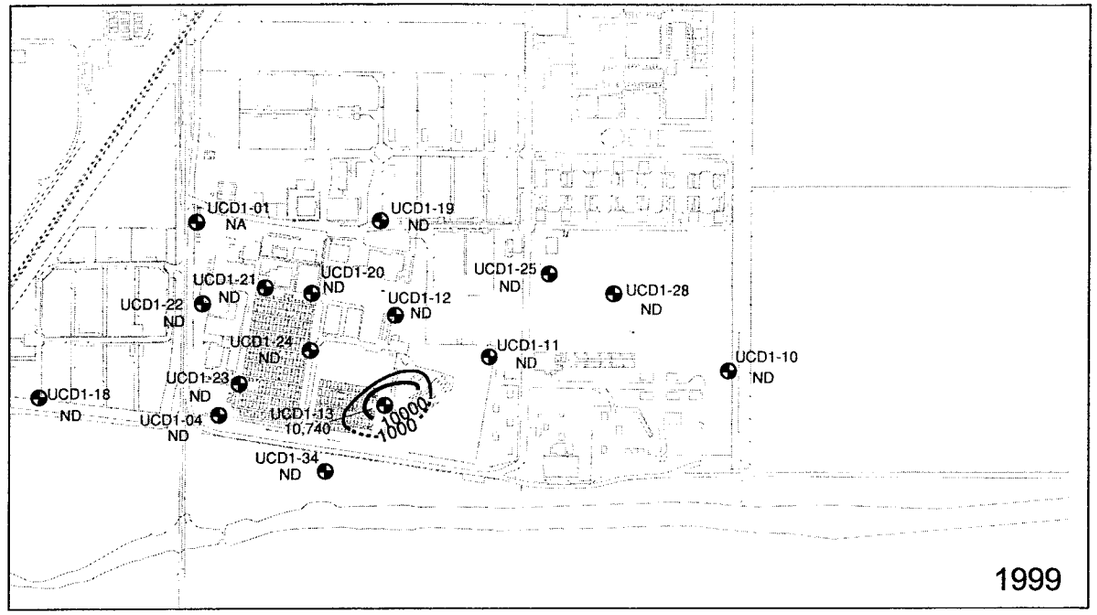

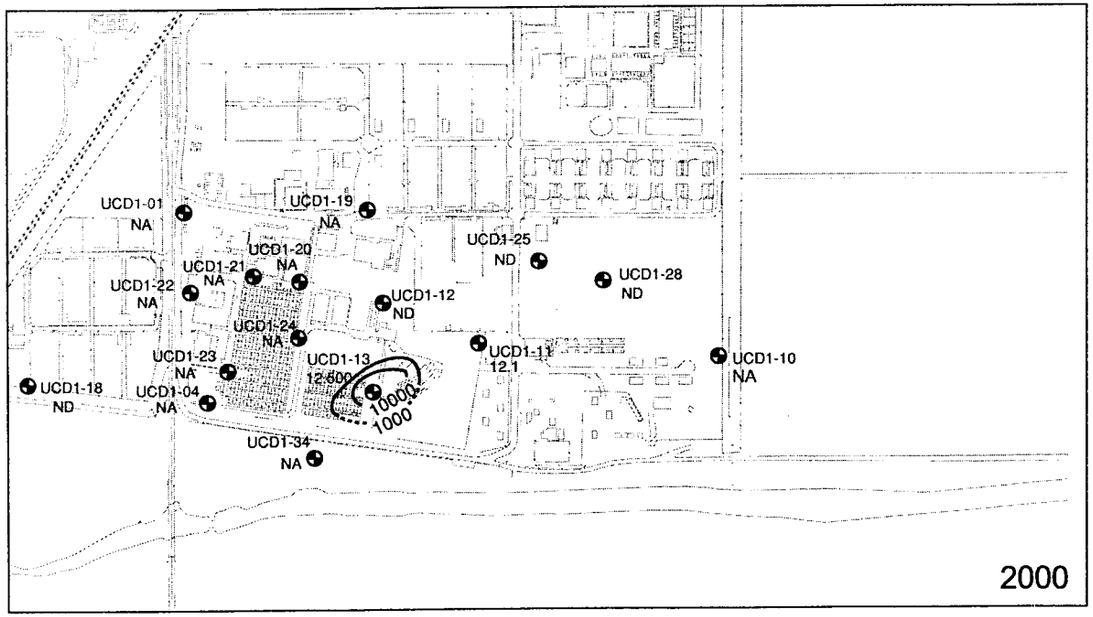

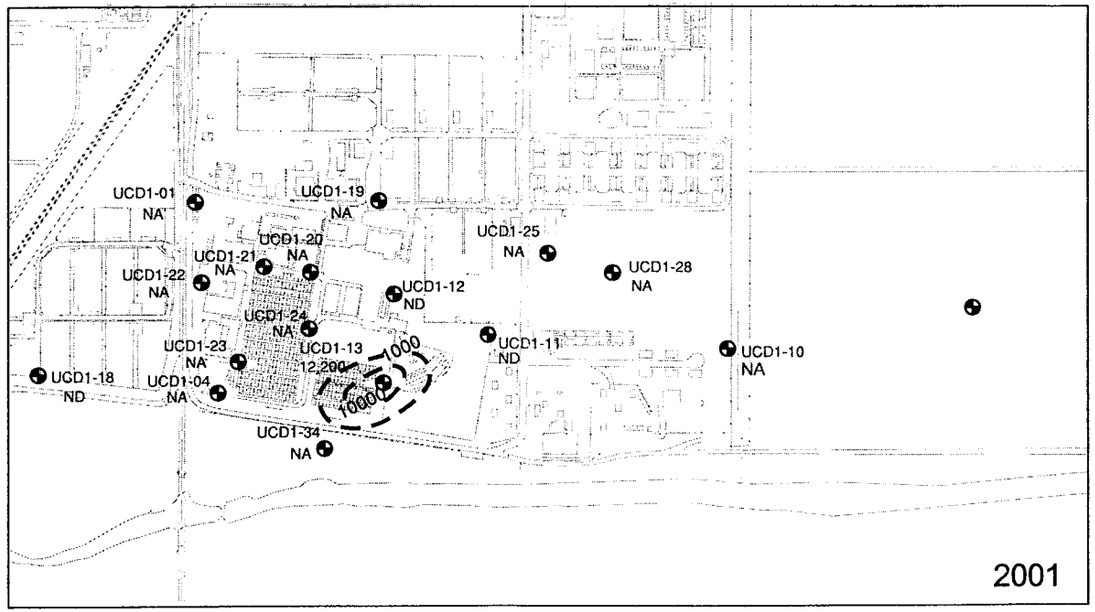

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All results reported in pCi/L
Results represent average of quarterly data
NA = Not Analyzed
ND = Not Detected

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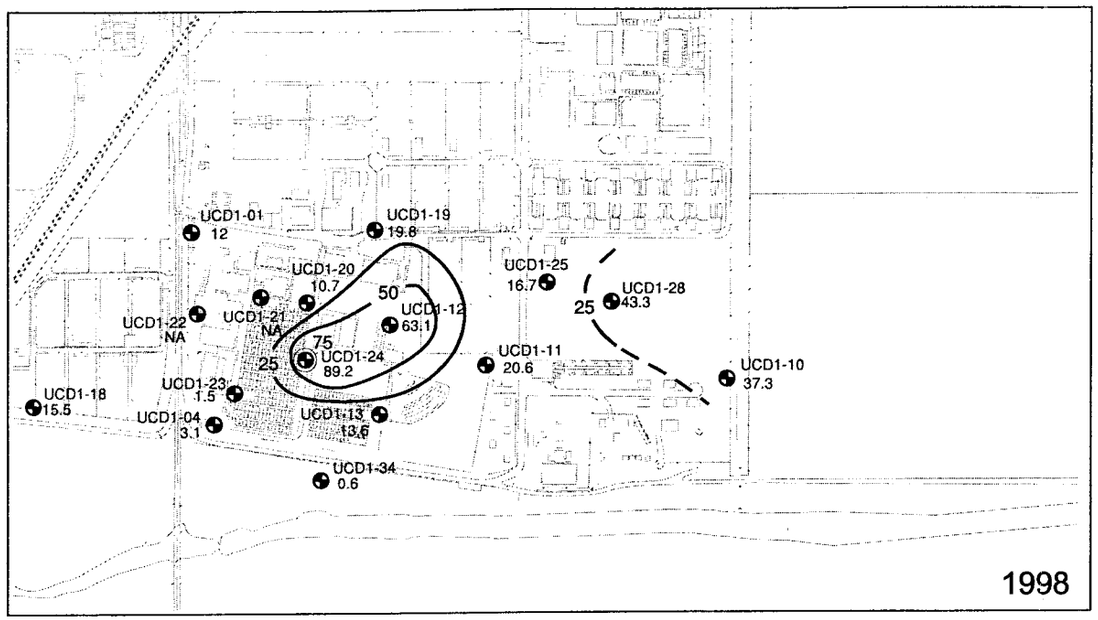

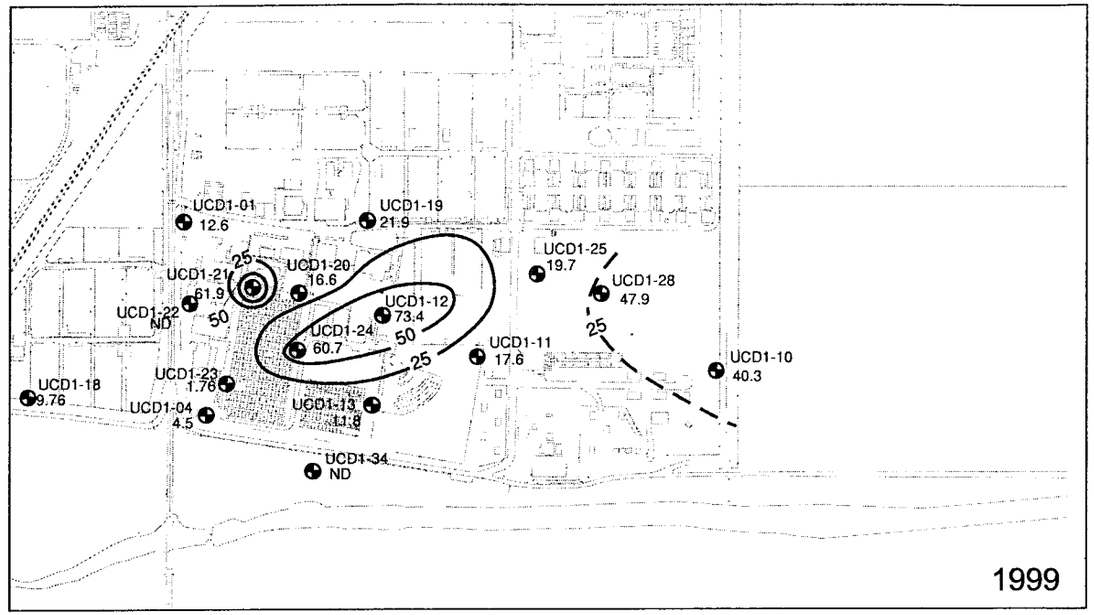

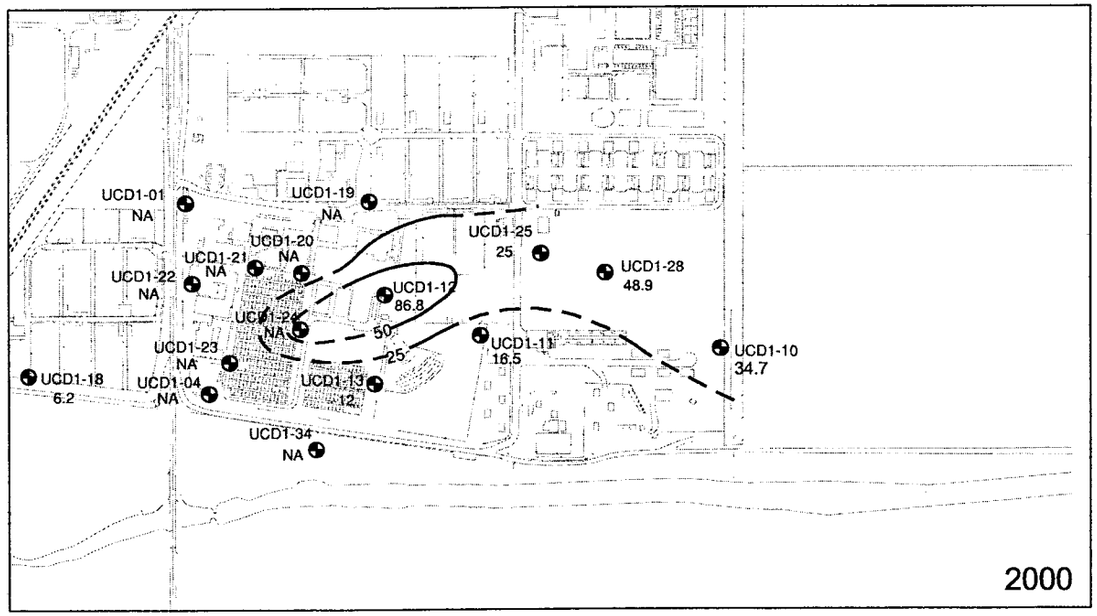

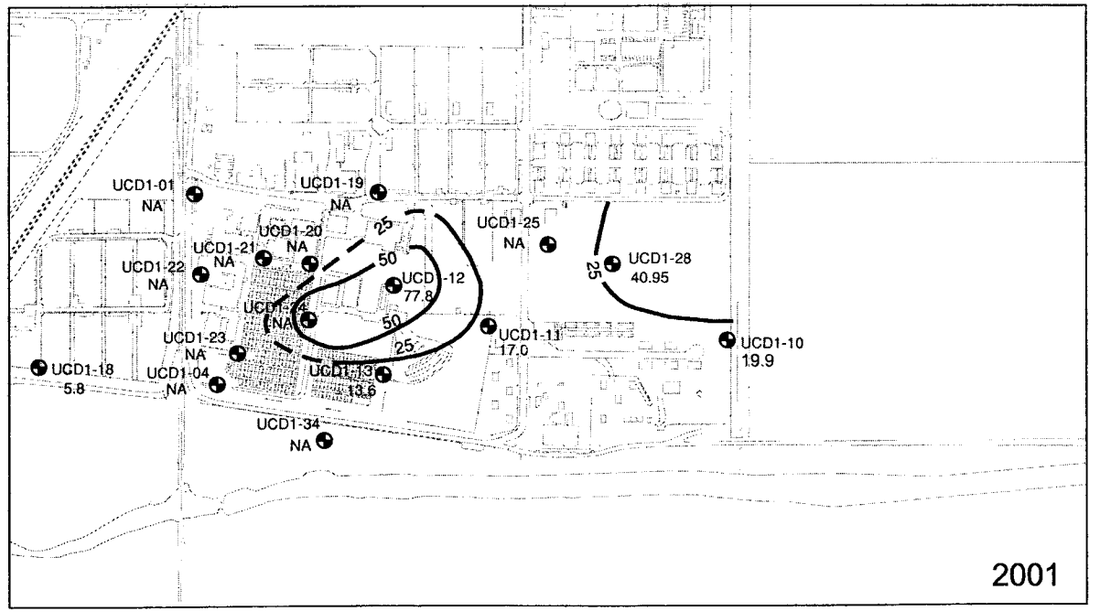

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- UCD2-17 HSU-2 Monitoring Well
- All results reported in mg/L
- Results represent average of quarterly data
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- ND = Not Detected

NITRATE AS N ISOCONCENTRATION CONTOURS IN HSU-1, 1998 THROUGH 2001

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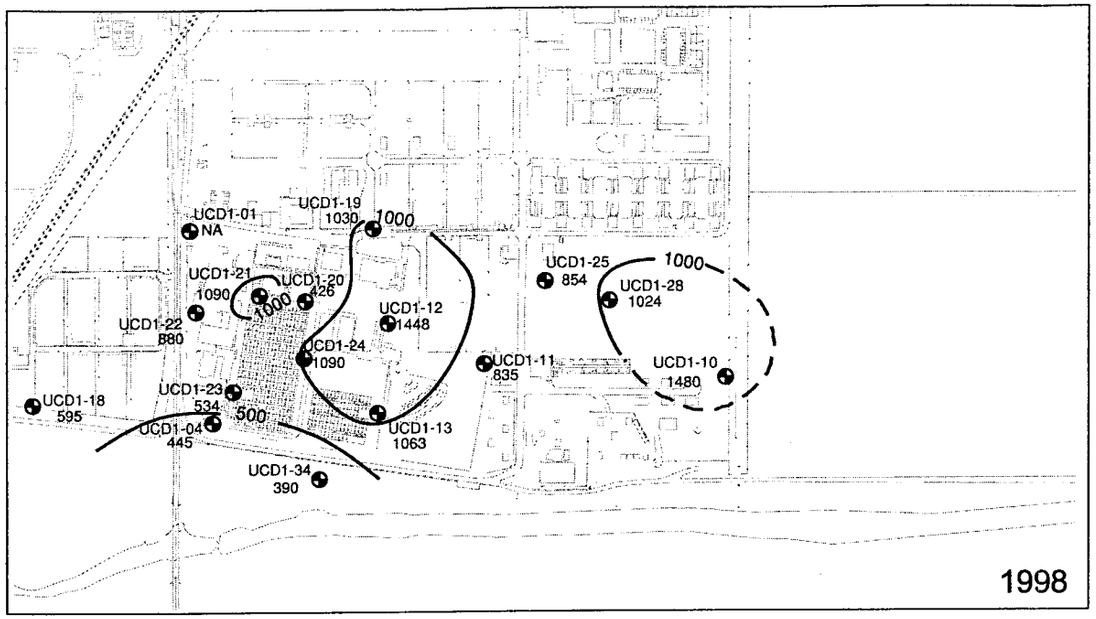

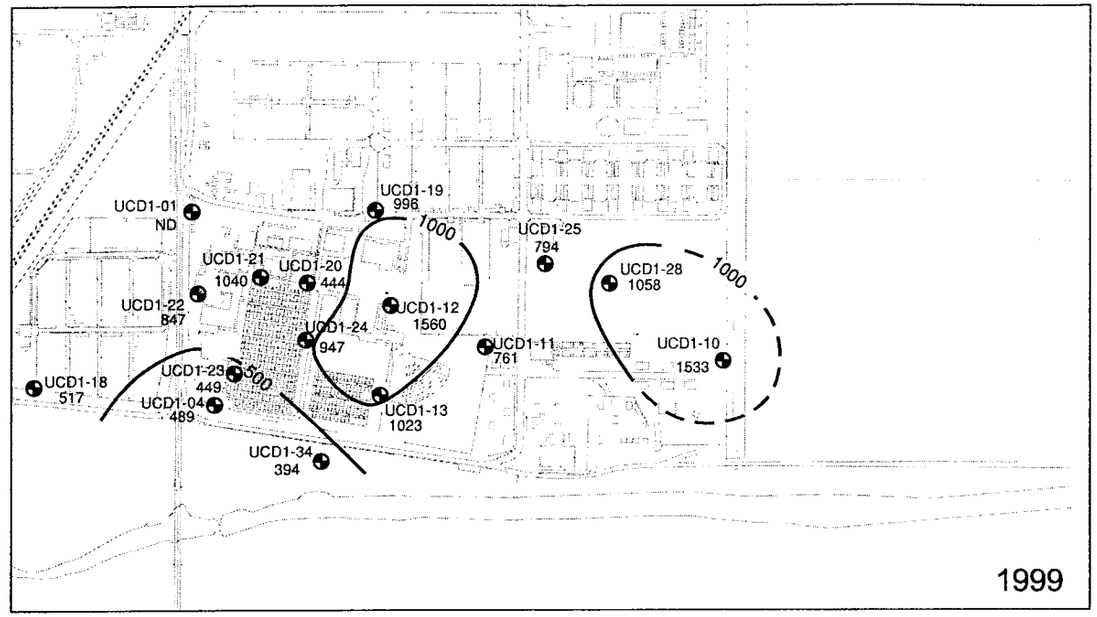

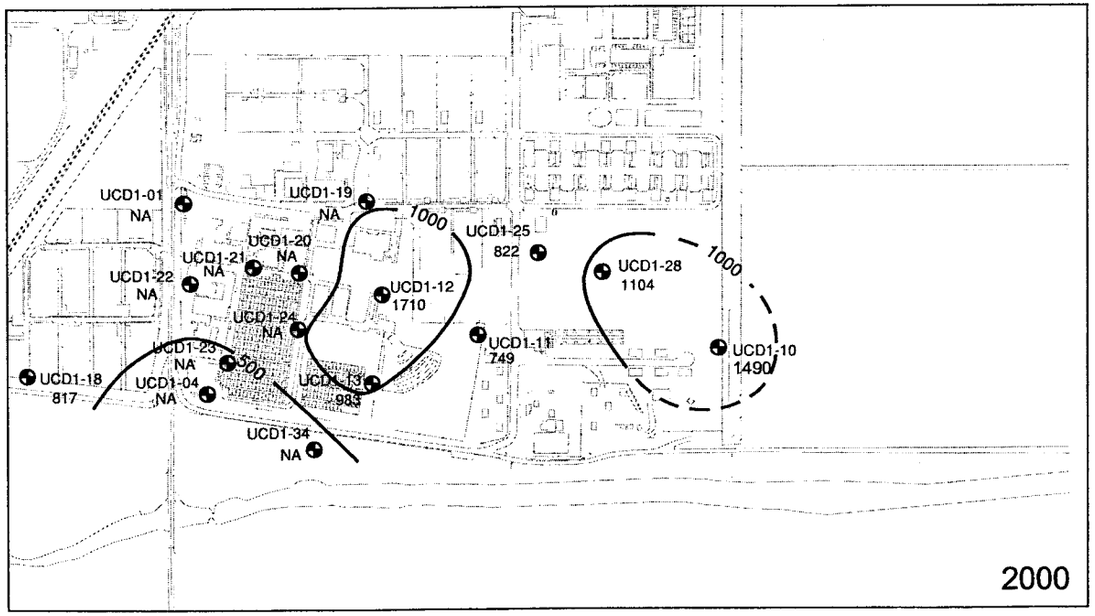

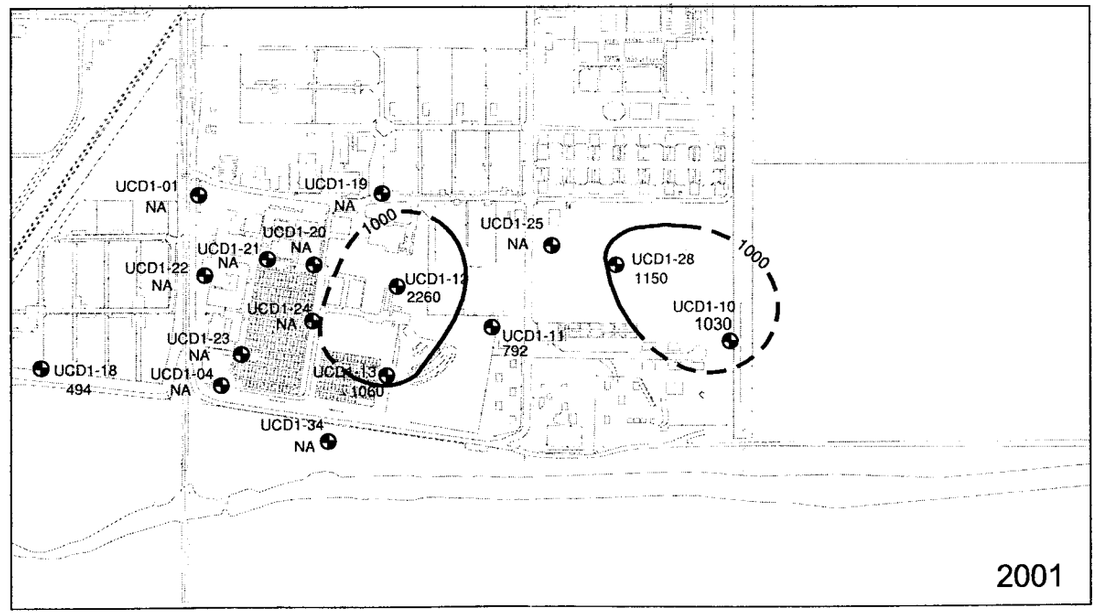

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UCD2-17 HSU-2 Monitoring Well
All results reported in pCi/L.
Results represent average of quarterly data
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ND = Not Detected

TDS ISOCONCENTRATION CONTOURS IN HSU-1, 1998 THROUGH 2001

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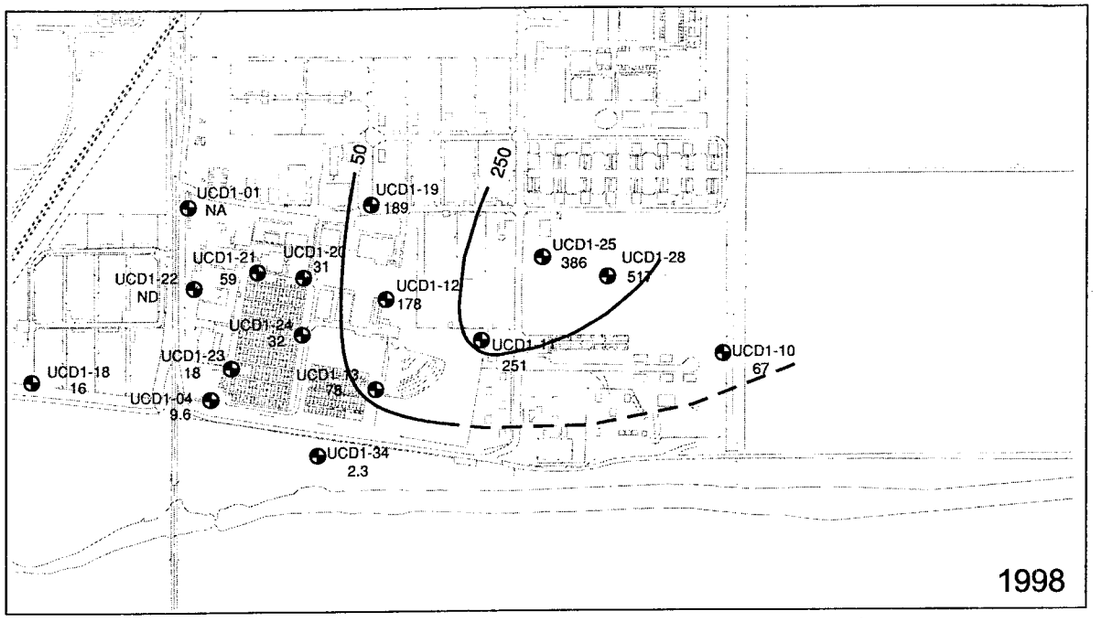

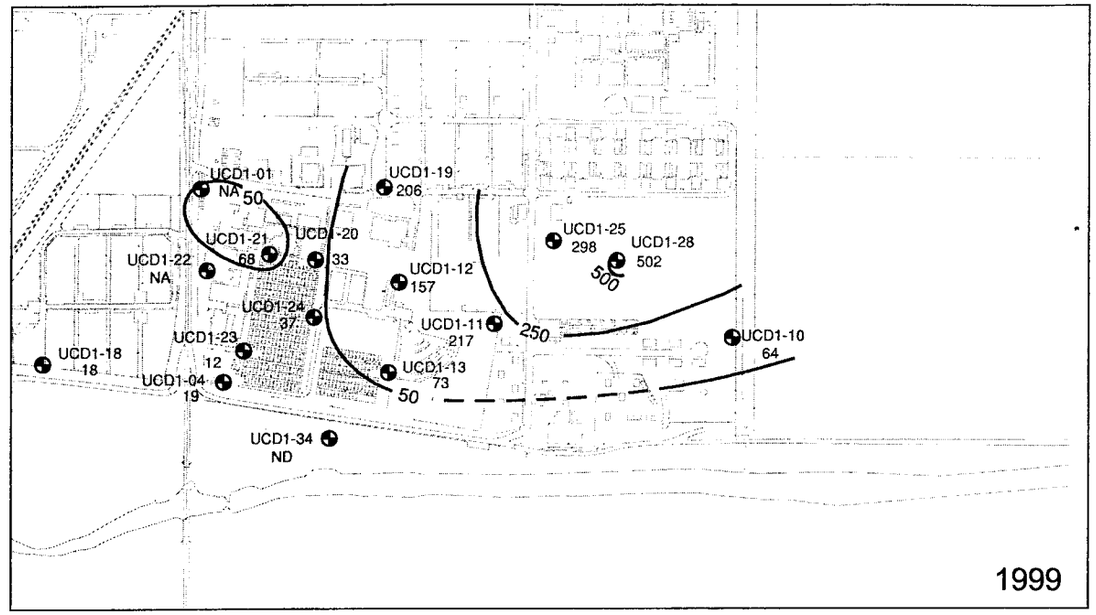

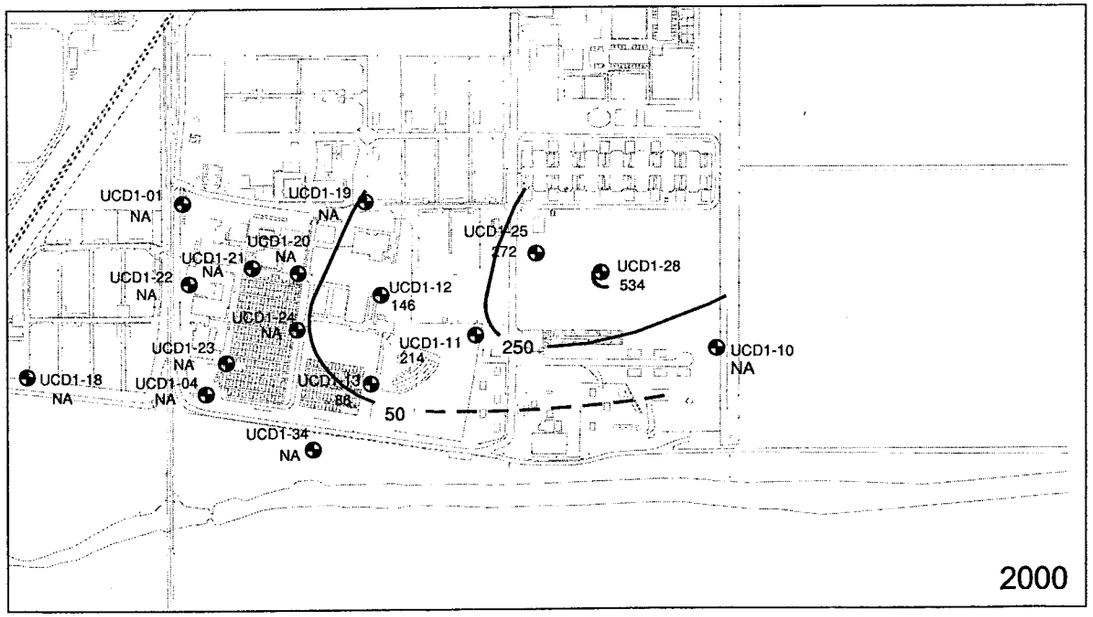

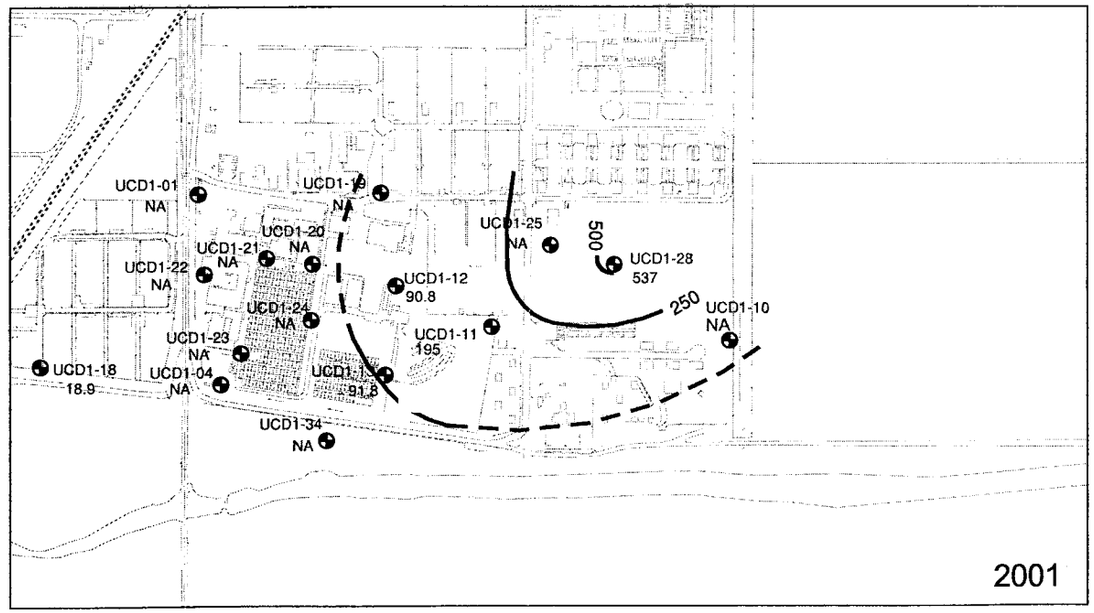

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- UCD2-17 HSU-2 Monitoring Well

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CHROMIUM ISOCONCENTRATION CONTOURS IN HSU-1, 1998 THROUGH 2001

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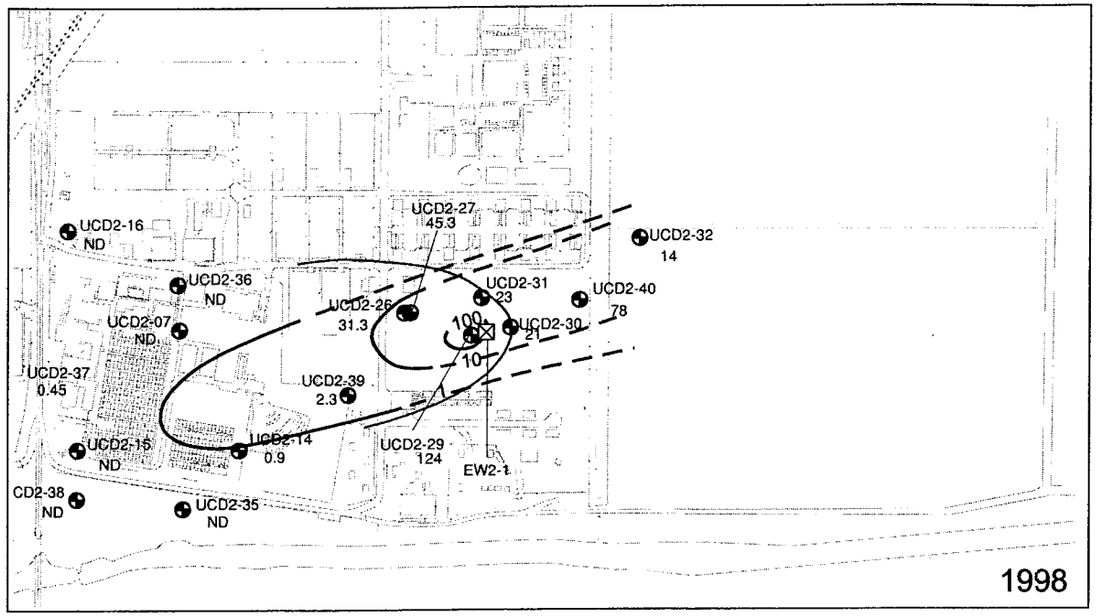

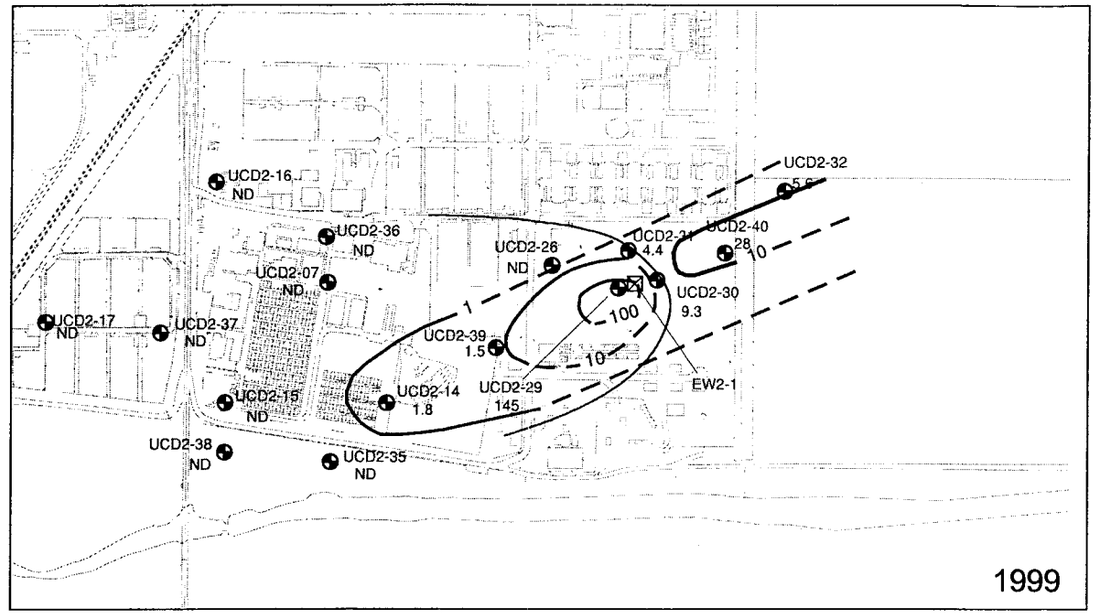

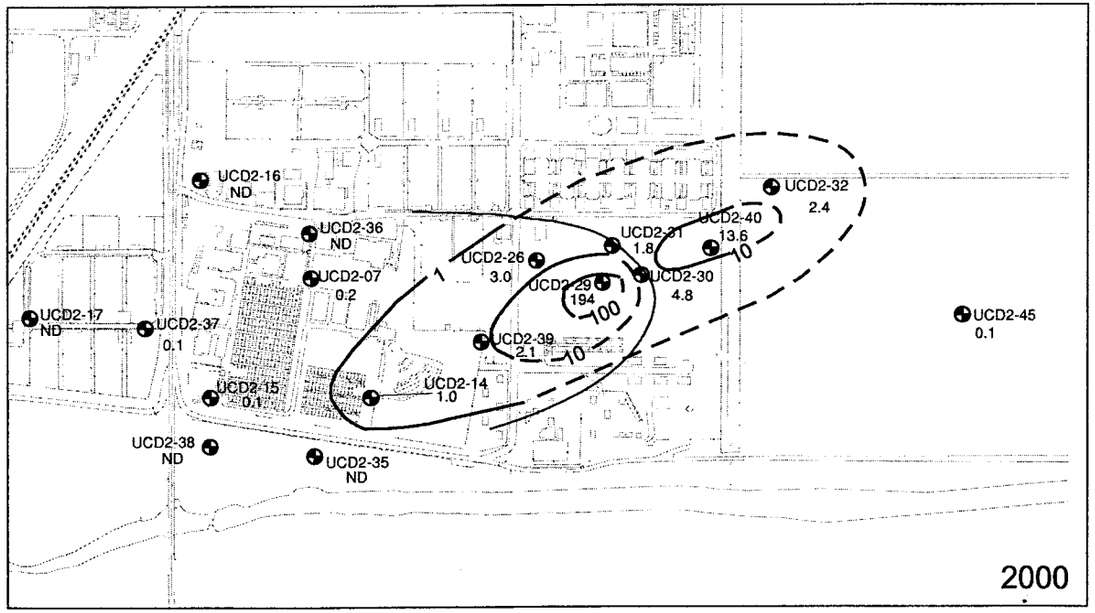

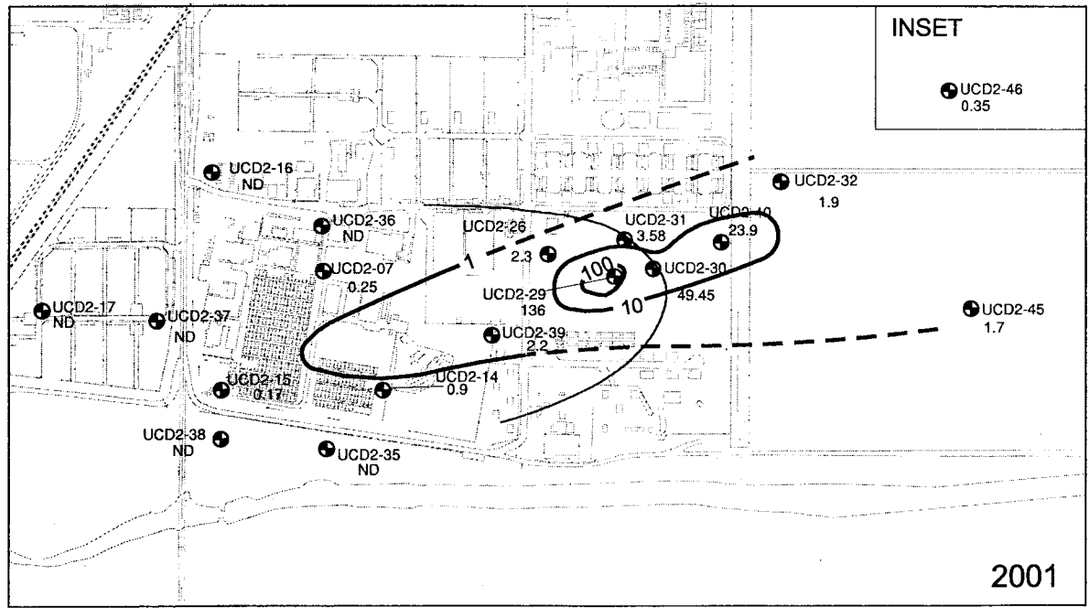

LEGEND

- UCD2-17 HSU-2 Monitoring Well
- All results reported in ug/L
- Results represent average of quarterly data
- NA = Not Analyzed
- ND = Not Detected
- Extraction Well Capture Zone

CHLOROFORM ISOCONCENTRATION CONTOURS IN HSU-2, 1998 THROUGH 2001

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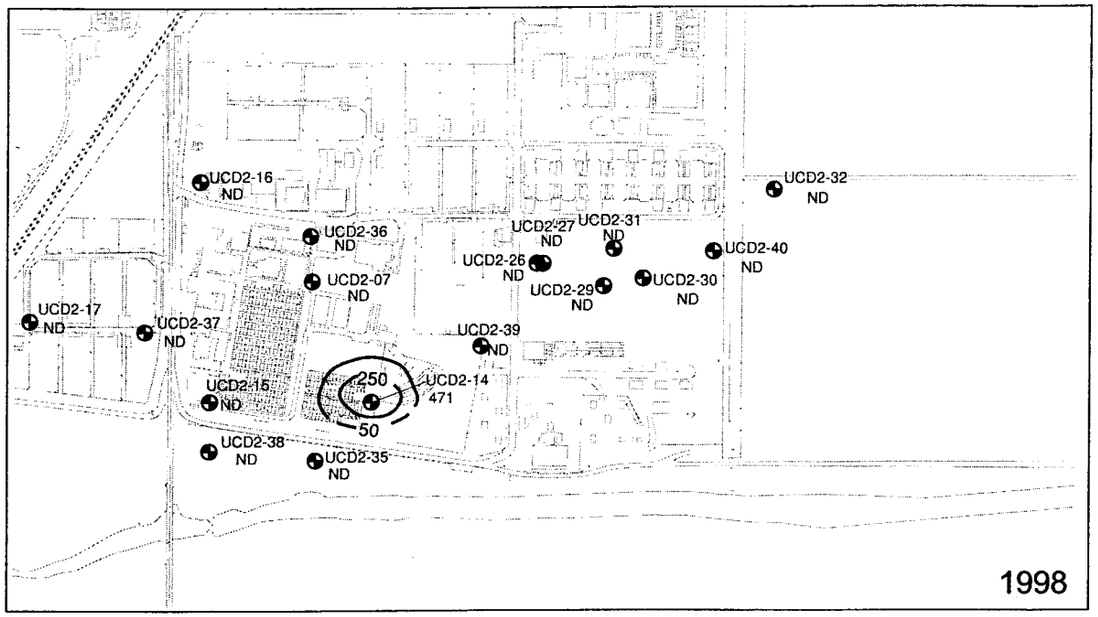

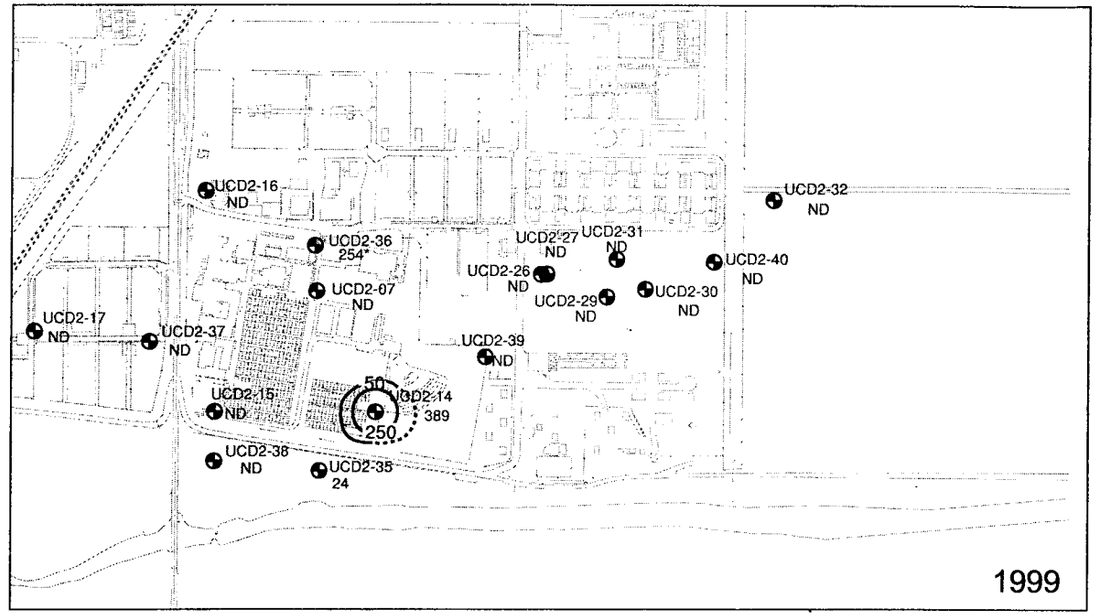

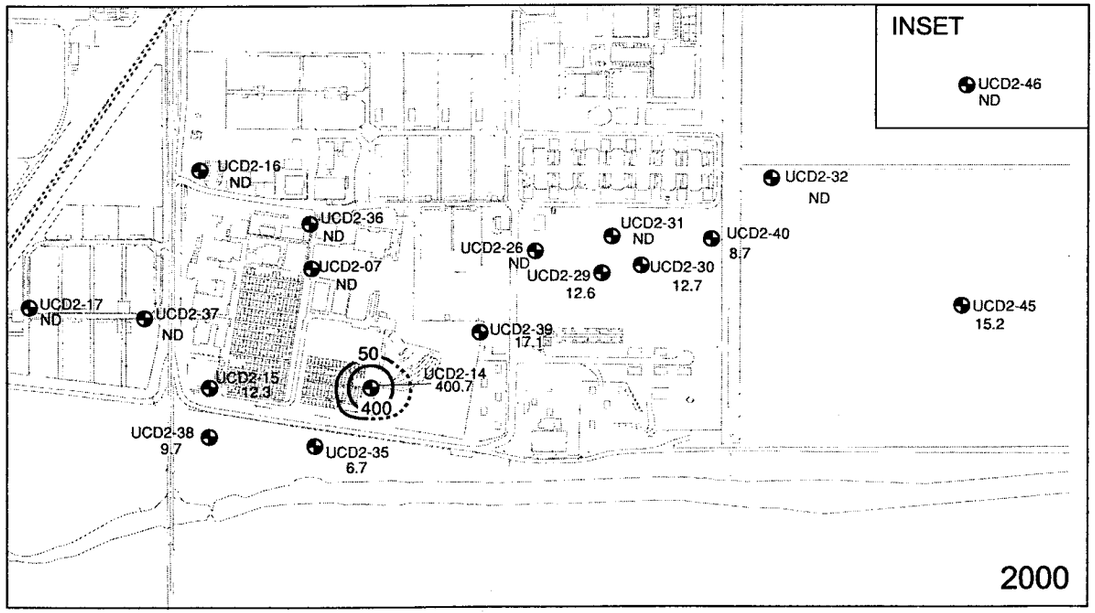

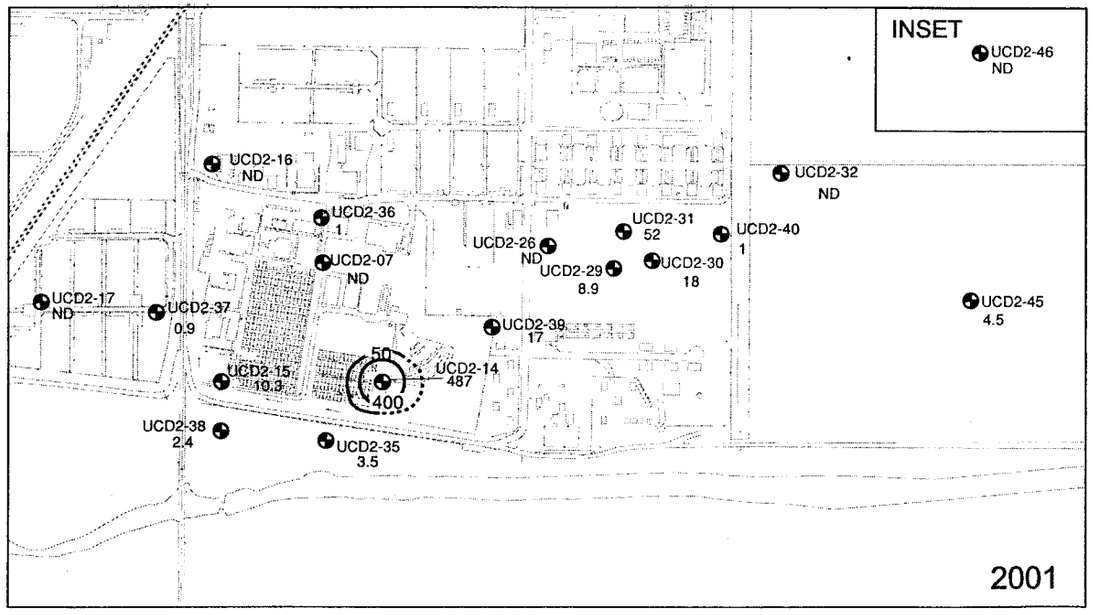

LEGEND

UCD2-17 HSU-2 Monitoring Well
All results reported in pCi/L
Results represent average of quarterly data
NA = Not Analyzed
ND = Not Detected

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CARBON-14 ISOCONCENTRATION CONTOURS IN HSU-2, 1998 THROUGH 2001

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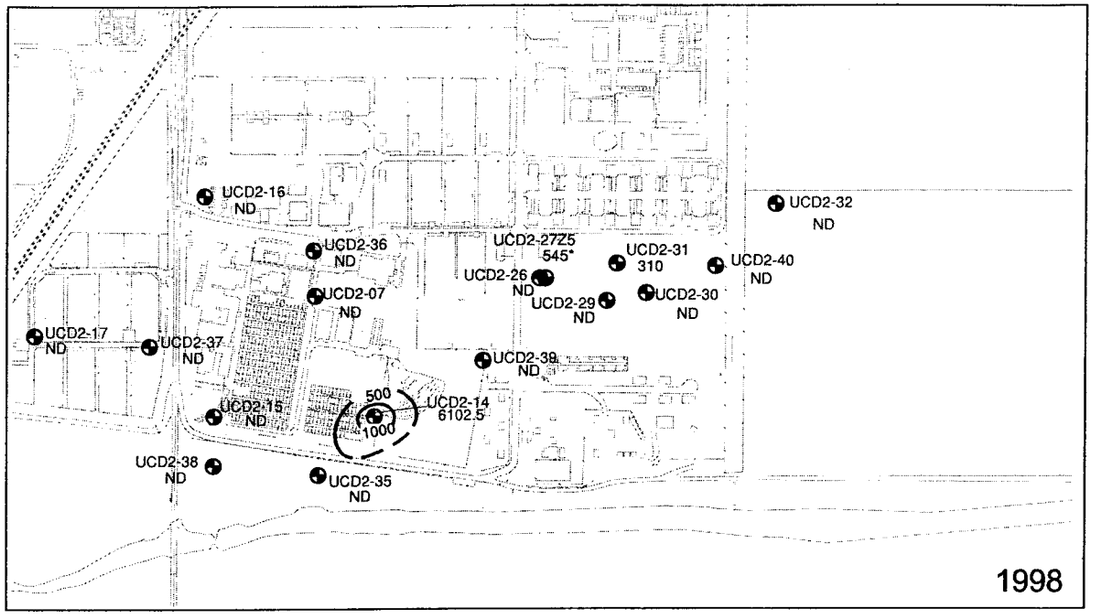

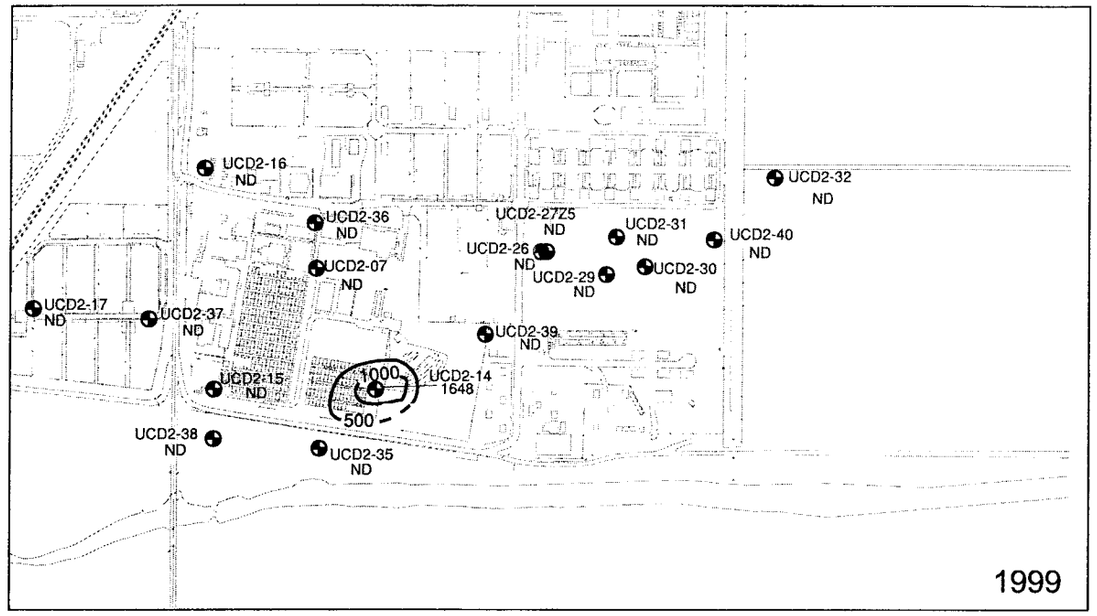

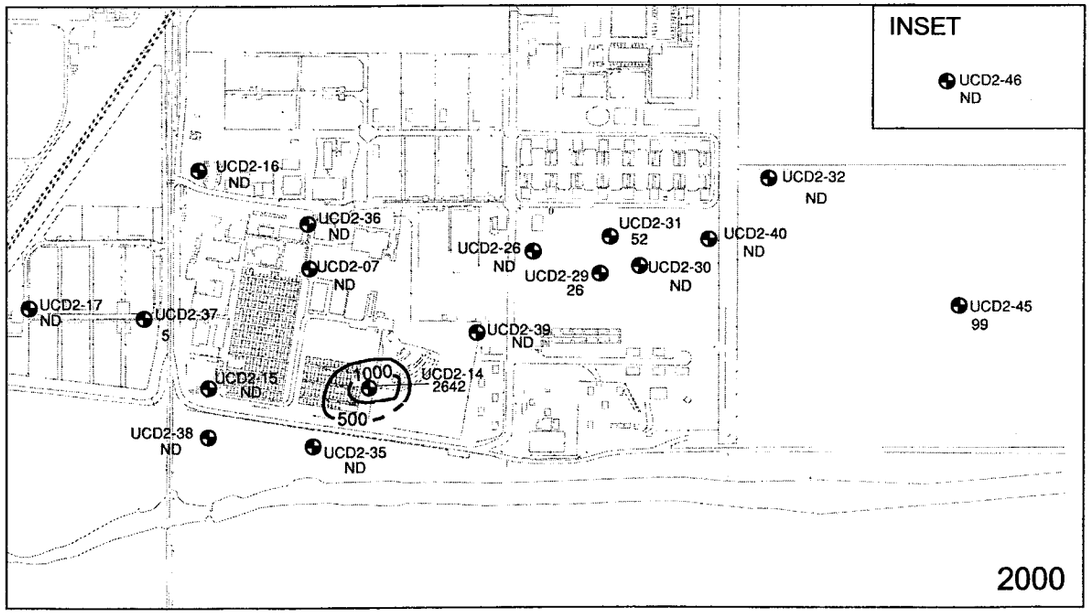

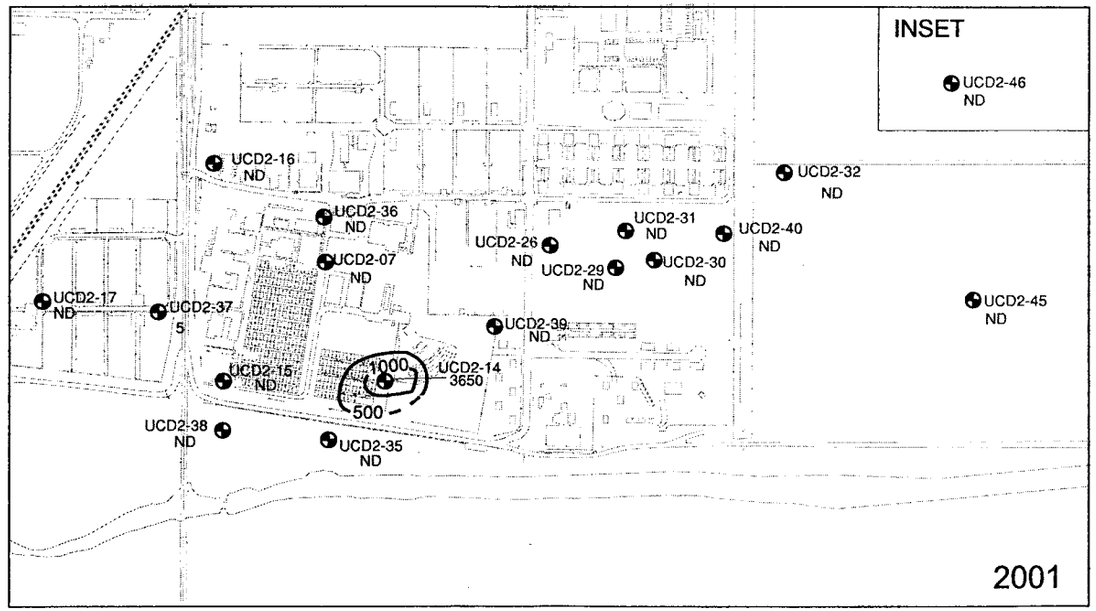

LEGEND

UCD2-17 HSU-2 Monitoring Well
All results reported in pCi/L
Results represent average of quarterly data
NA = Not Analyzed
ND = Not Detected

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TRITIUM ISOCONCENTRATION CONTOURS IN HSU-2, 1998 THROUGH 2001

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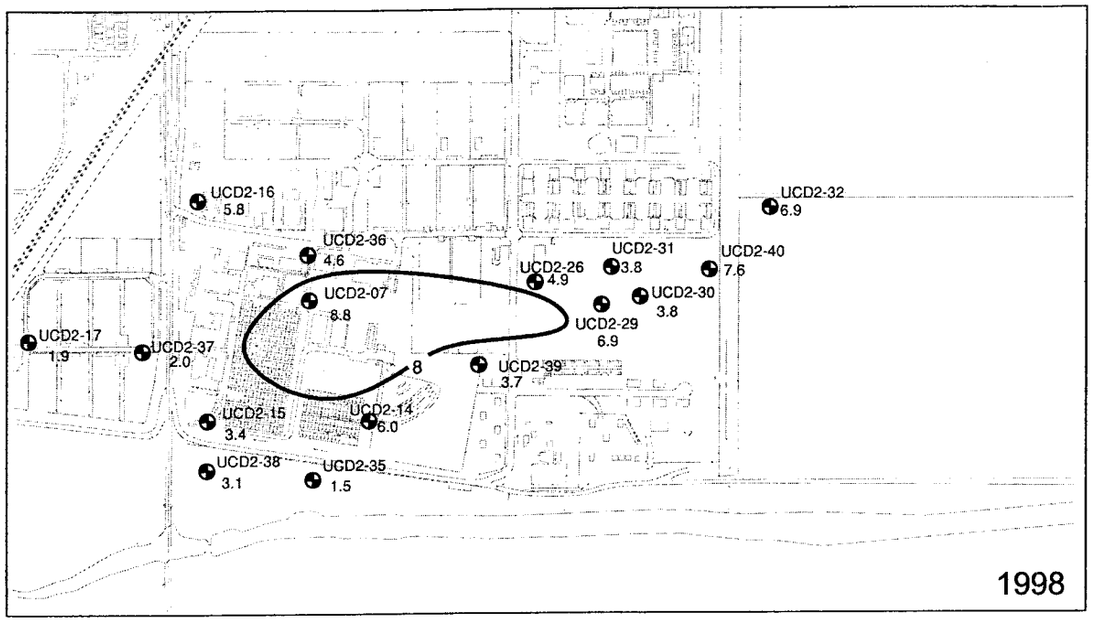

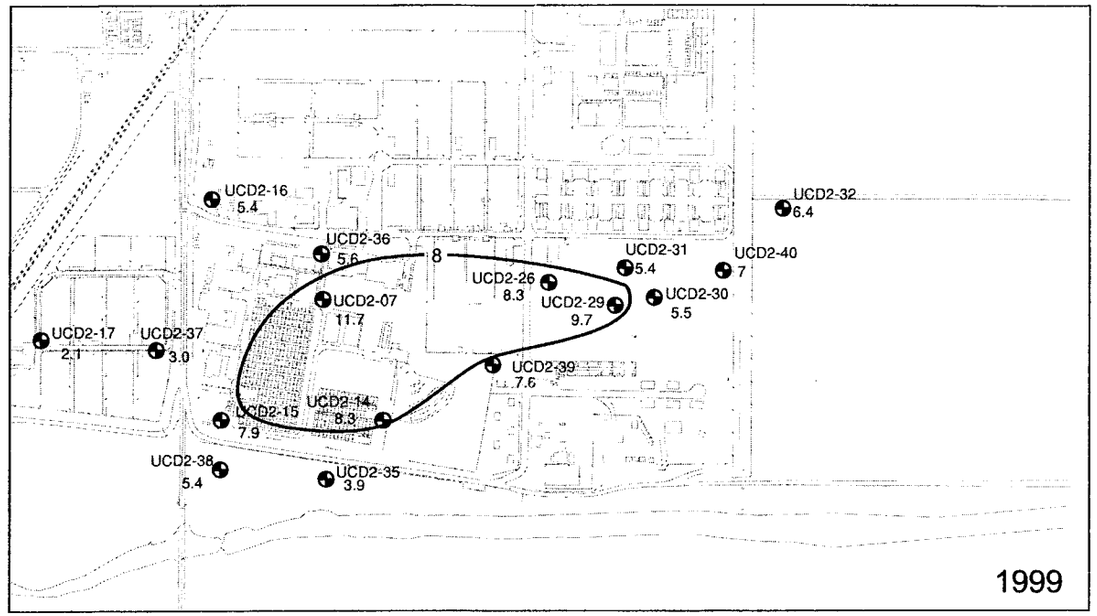

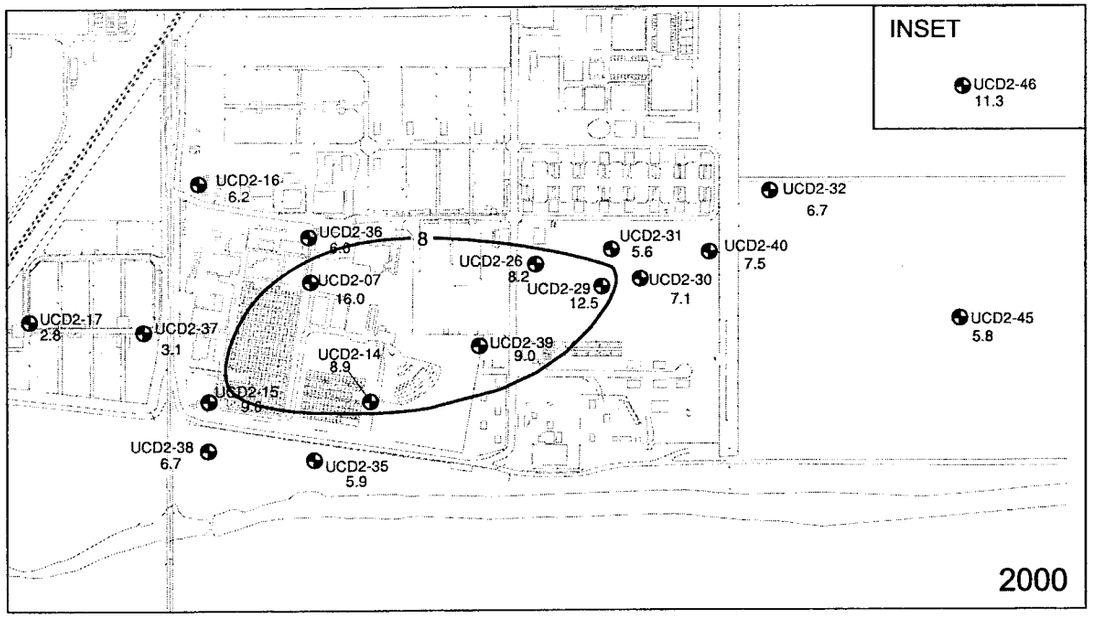

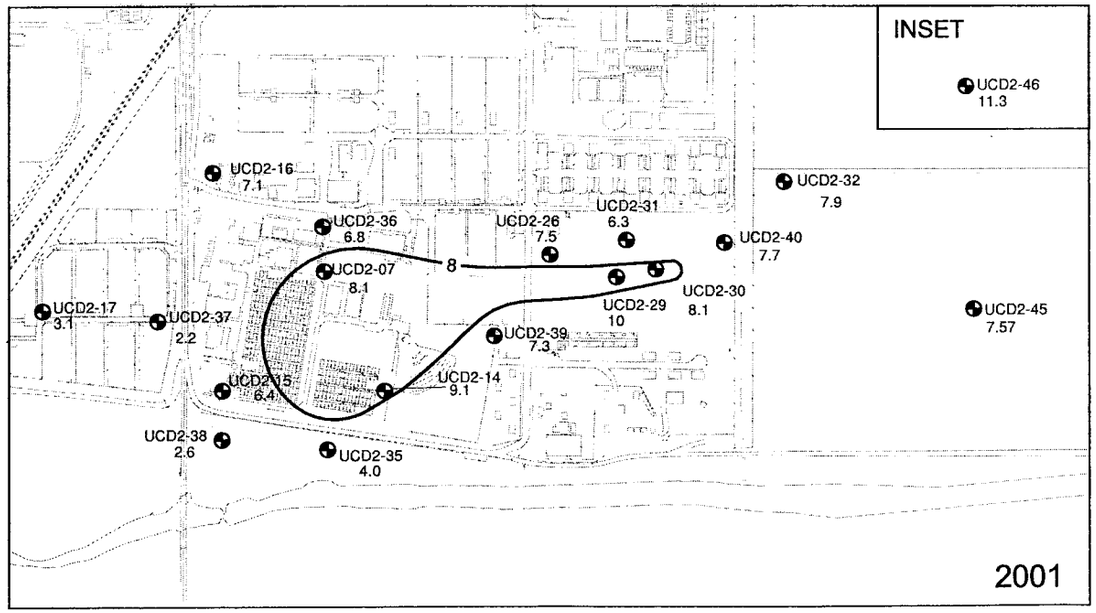

LEGEND

UCD2-17 HSU-2 Monitoring Well
All results reported in mg/L
Results represent average of quarterly data
NA = Not Analyzed
ND = Not Detected

NITRATE AS N ISOCONCENTRATION CONTOURS IN HSU-2, 1998 THROUGH 2001

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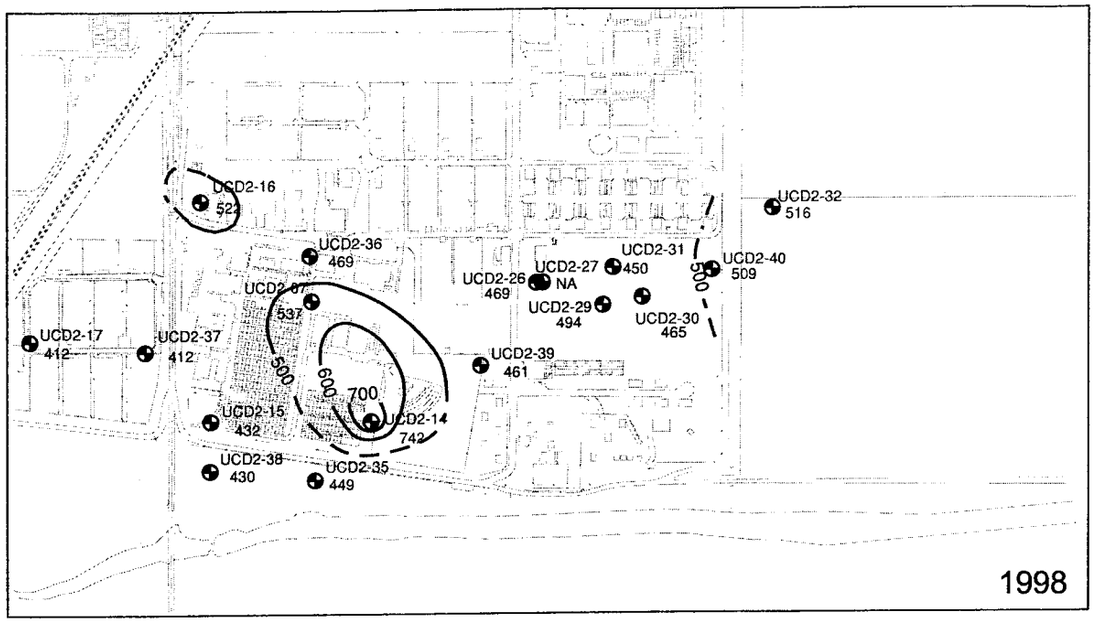

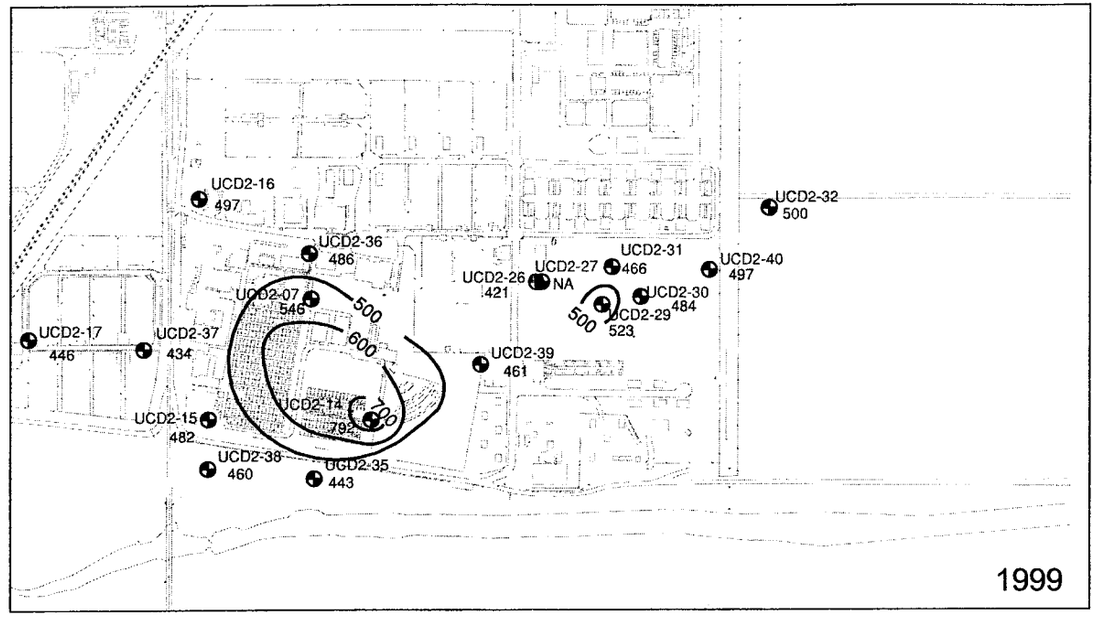

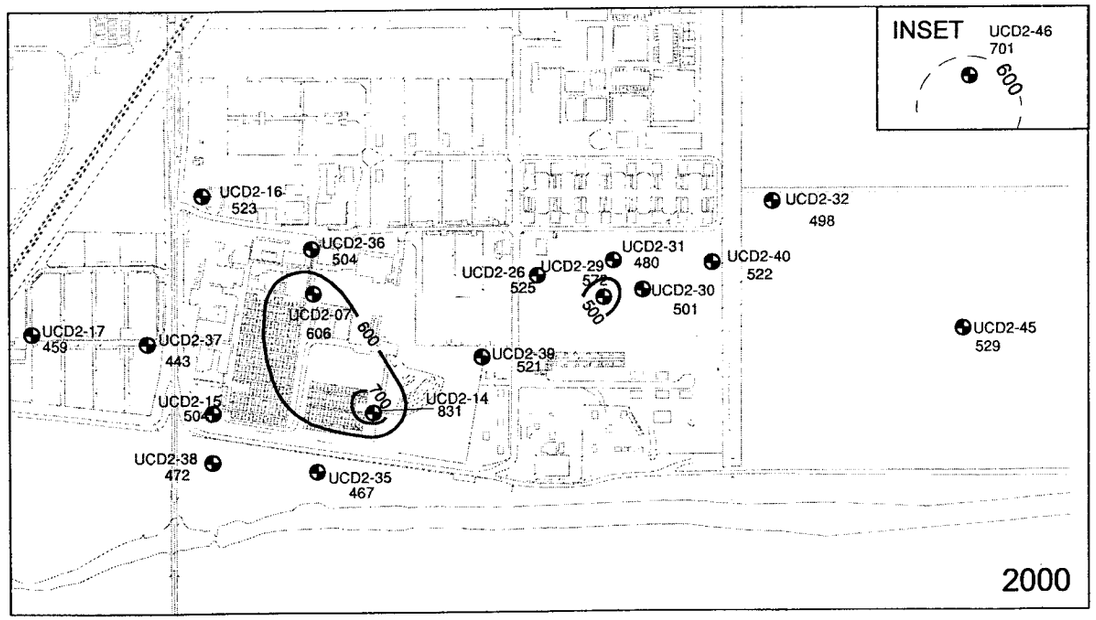

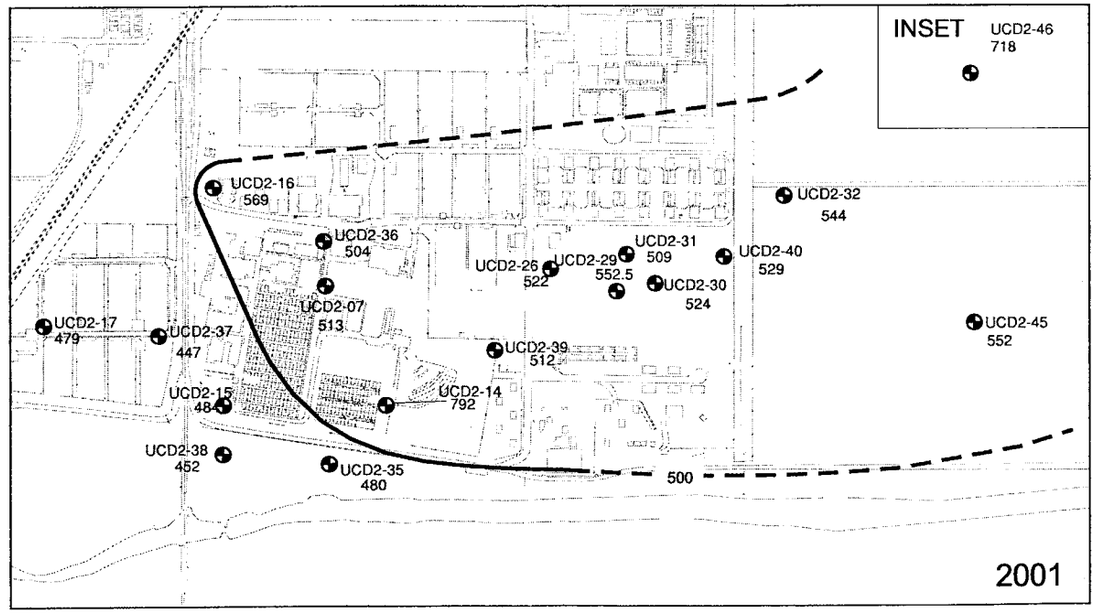

LEGEND

- UCD2-17 HSU-2 Monitoring Well
- All results reported in mg/L.
- Results represent average of quarterly data
- NA = Not Analyzed
- ND = Not Detected

TDS ISOCONCENTRATION CONTOURS IN HSU-2, 1998 THROUGH 2001

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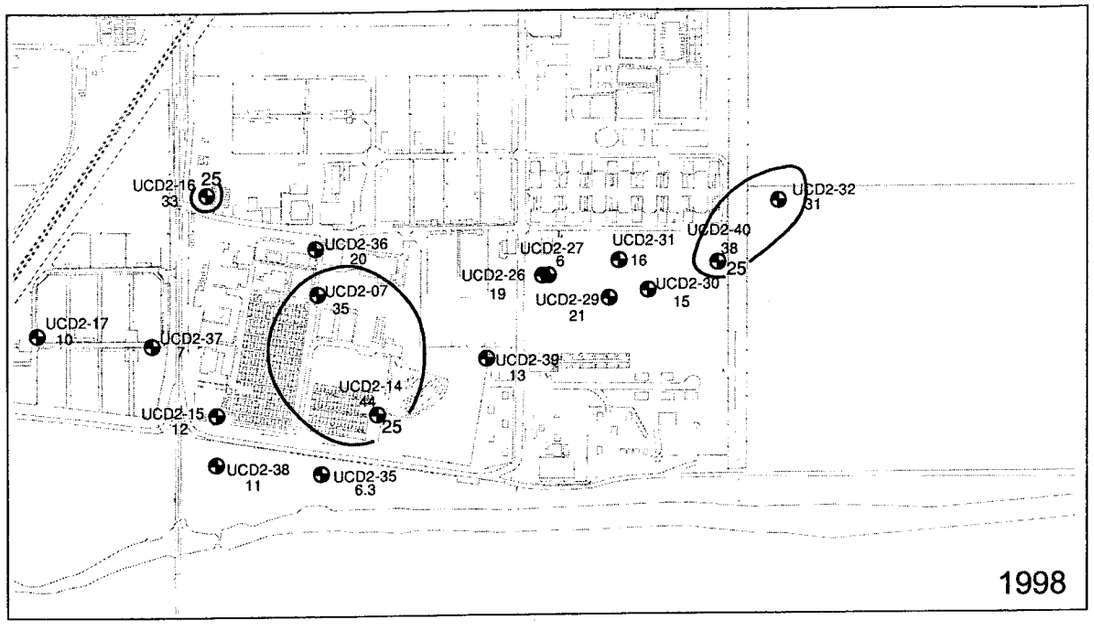

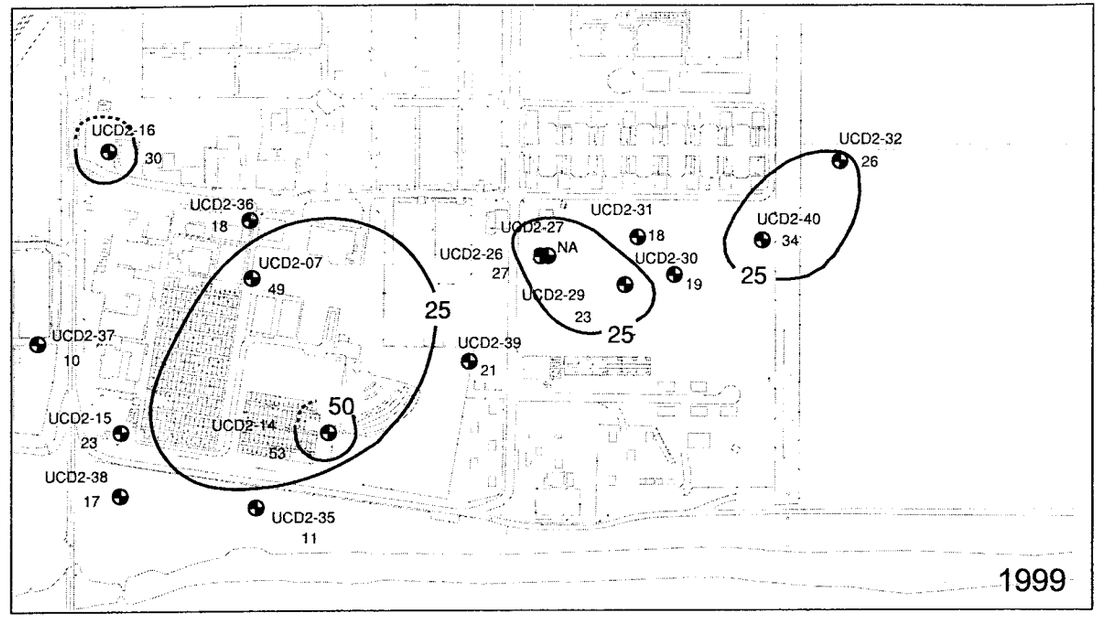

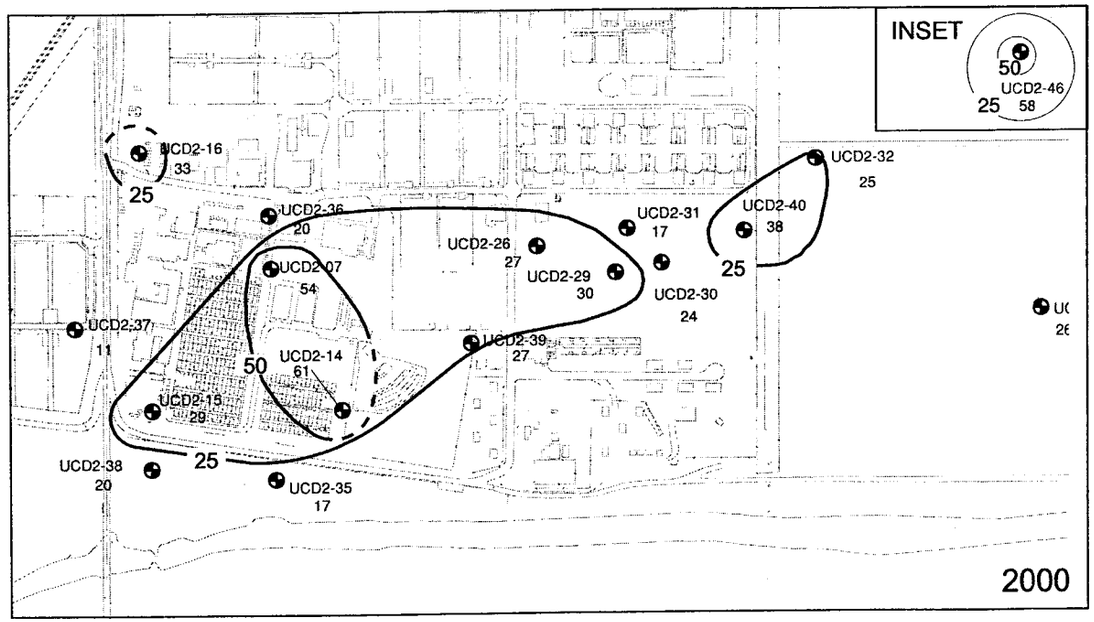

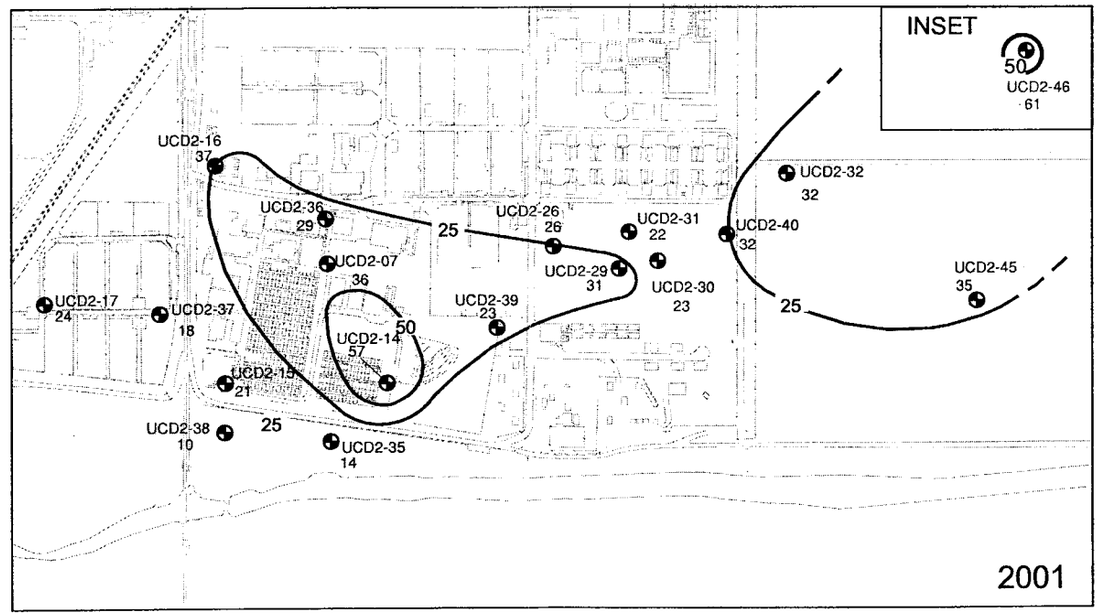

LEGEND

- UCD2-17 HSU-2 Monitoring Well
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CHROMIUM ISOCONCENTRATION CONTOURS IN HSU-2, 1998 THROUGH 2001

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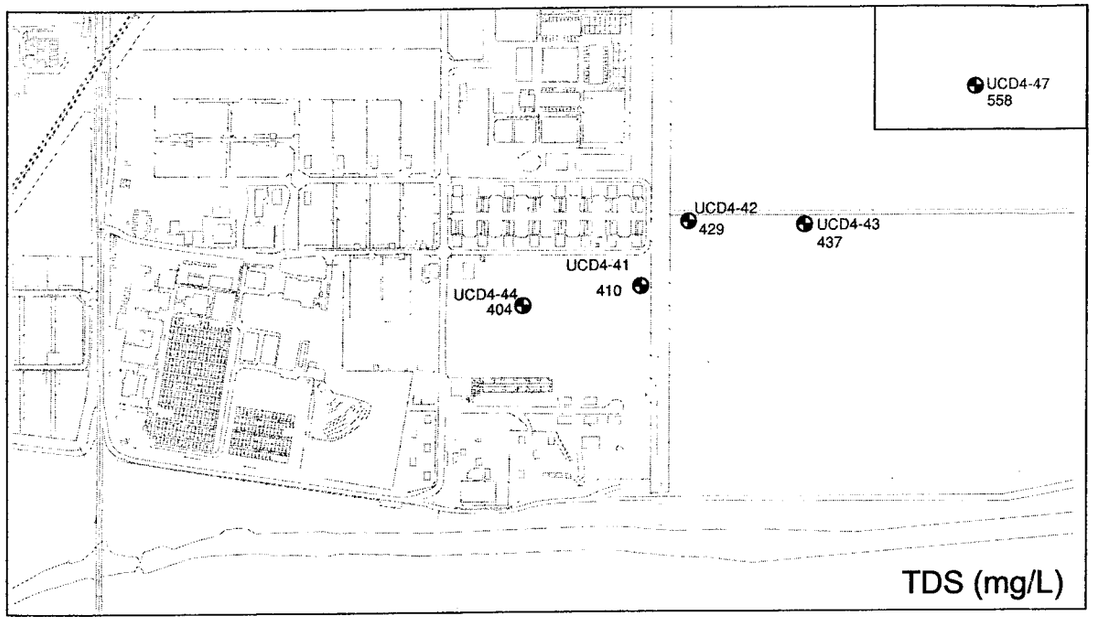

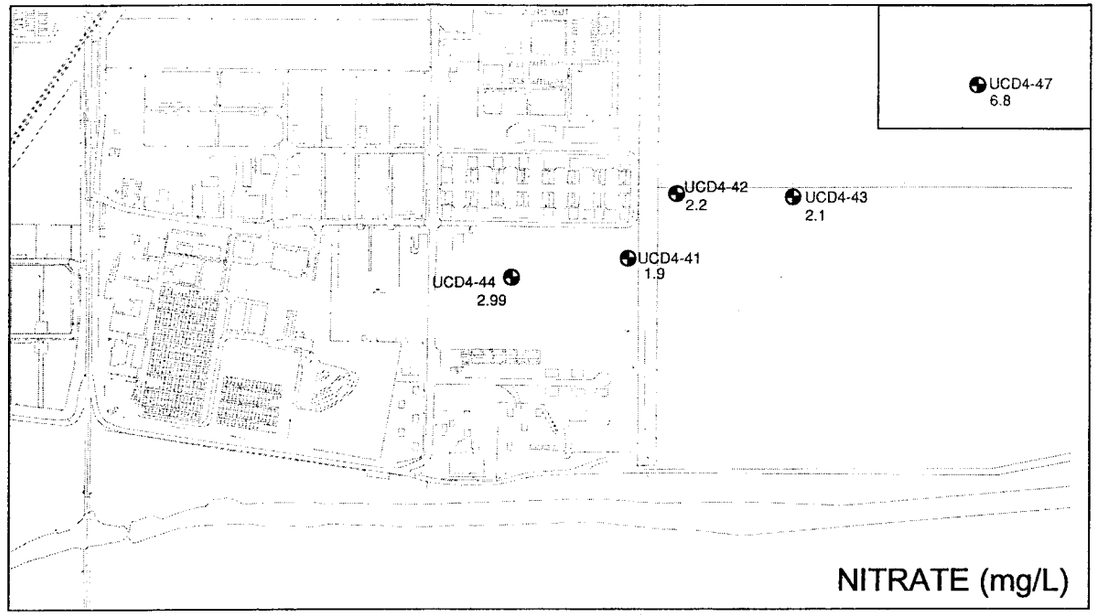

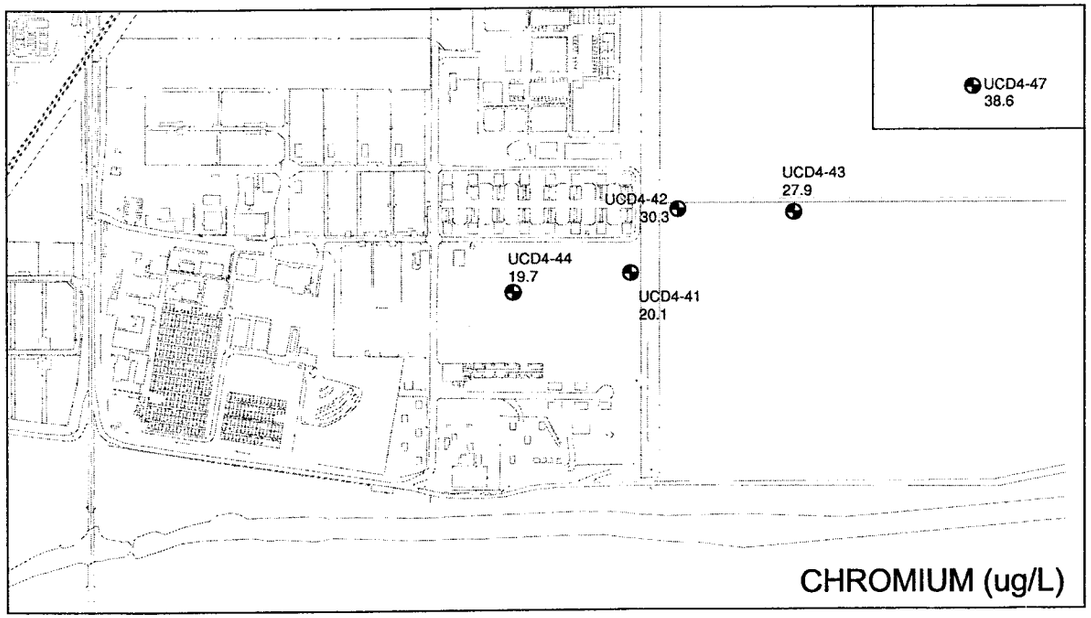

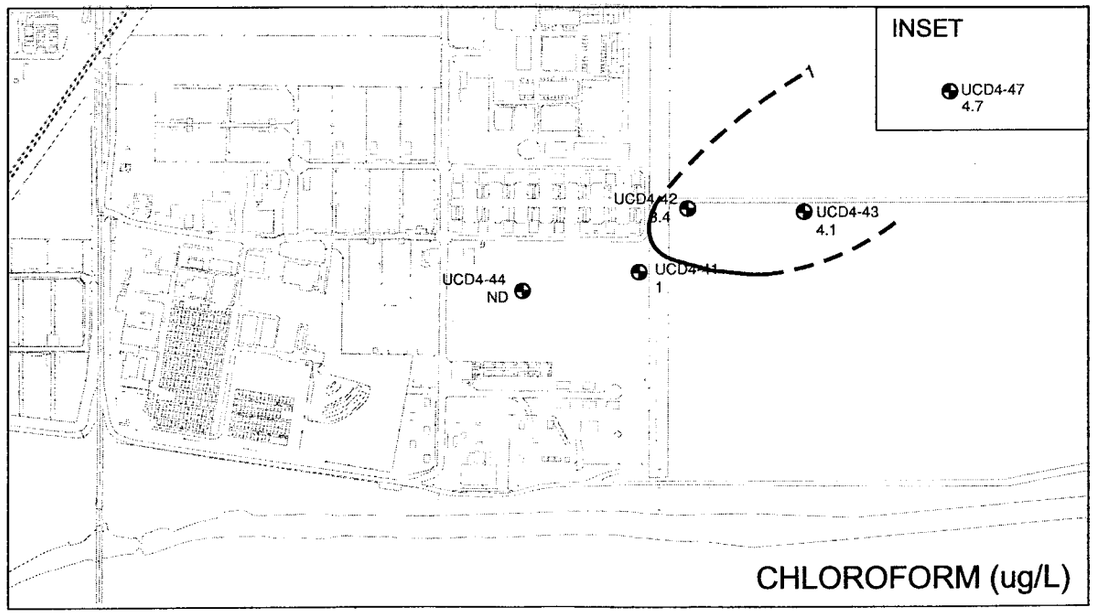

LEGEND

- UCD2-17 HSU-2 Monitoring Well
- All results reported in pCi/L
- Results represent average of quarterly data
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- ND = Not Detected

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ISOCONCENTRATION CONTOURS IN HSU-4 2001

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